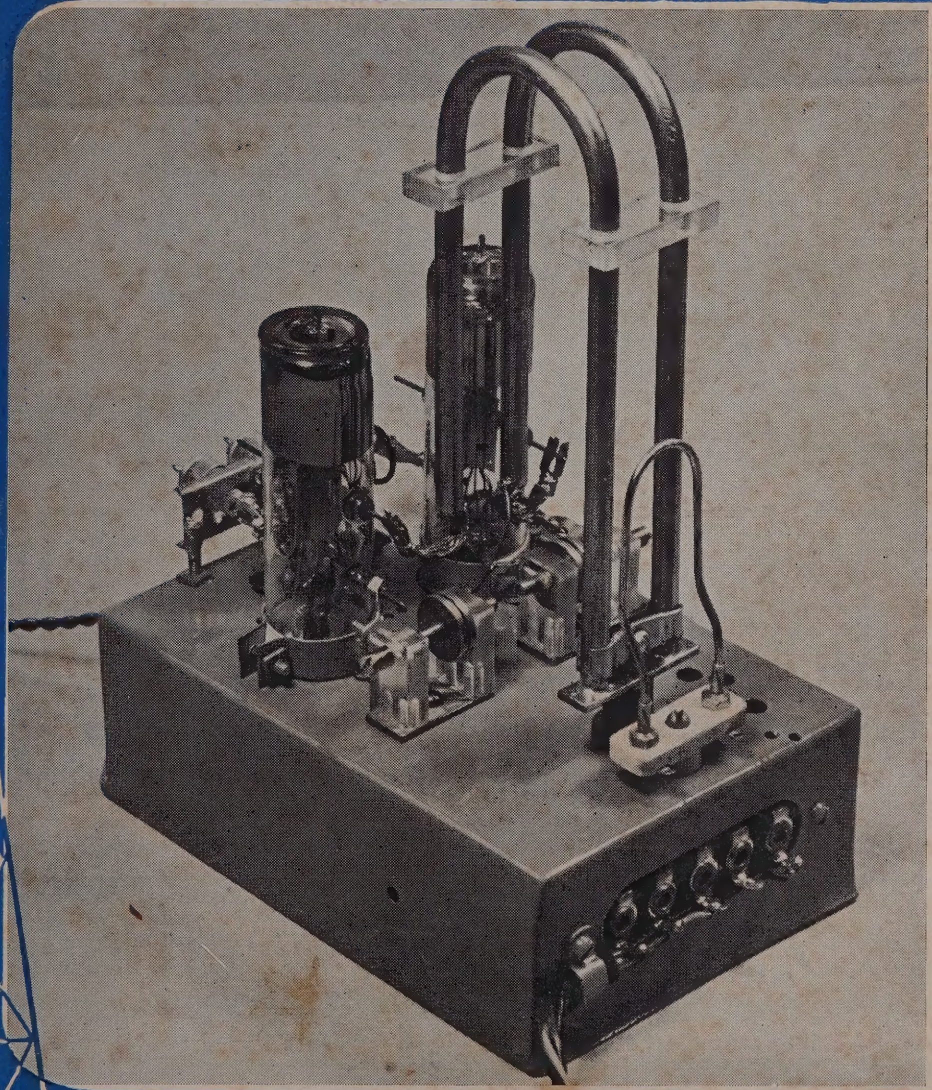
RADIO and ELECTRONICS

ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND



In this Issue:

The "Rainbow" Communications Receiver

An Electronics Switch for Oscilloscope Use

Applying the 8012

For the Serviceman

EASTER, 1949

VOL. 4, NO. 2

1/10

"BRS"

DISC RECORDER AND PLAYBACK UNIT

Model R-12

DUAL SPEED

Made by Byer Industries Pty. Ltd.

This recorder-playback unit has been designed and manufactured for use by professional and amateur recordists who require a machine capable of recording at 78 r.p.m. and 33 1-3 on 12-inch, or smaller, discs for immediate playback purposes. Simplicity of operation, robust construction, faithful recording and reproduction, and pleasing appearance were the essentials borne in mind when planning and producing this unit. Recordings may be made on acetate base discs when connected in accordance with the instructions to any amplifier or high-grade radio having pick-up connection facilities.

As a recorder, the unit may be put to any one of many uses, amongst which are included the following:—

In the Home: Record your children, your favourite programme, musical items at parties, commentary for films, surprise recordings of friends.

For Artists: Recordings of voice or instrument for comparison and self-analysis.

For the Business Man: Recordings of speeches, company meetings, sales conventions, etc.

As a playback unit, this machine provides a constant-speed turntable and a pick-up unit suitable for playing all lateral recordings up to 12-inch with remarkable fidelity.

The cutting-arm is accurately counterbalanced by an adjustable spring to give the correct weight at the needle-point. The cutting head is of the moving-iron type, giving a good response both for cutting and playback up to 6,000 cycles per second, the one head performing both functions.

This Recorder was described fully in "Radio and Electronics" of 1st February, 1949.

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RADIO and ELECTRONICS

Vol. 4, No. 2 Easter, 1949

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OUR COVER:

This month we have a picture of the 144 mc/sec. neutralized amplifier which is fully described elsewhere in this issue. It is capable of outputs up to 40 watts on this frequency, and uses a pair of the recently available 8012 V.H.F. triodes whose characteristics were published in our last issue.

THE CHANGE IN DATING:

As stated last month, the present issue has been labelled "Easter, 1949." Unfortunately, due to an oversight, some of the pages have been wrongly marked "2nd May, 1949." We would like to resolve possible confusion by indicating here that the front-cover marking of "Easter, 1949," is the correct one, in accordance with last month's statement.

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ELECTRONICS IN HEAVY ENGINEERING

In spite of the almost unlimited applications that can be visualized for electronic circuitry in aiding the design and performance of engineering projects, not themselves electronic by nature, there has been, and still is, a reluctance on the part of electrical and mechanical engineers to incorporate such equipment as an integral part of the whole.

This reluctance can be regarded on the one hand as lack of foresight, or as justified conservatism on the other, depending on the point of view. It is not for us to say that either view is correct, nor would we wish to do so, since to us it appears that there is right on both sides. There can be no real justification for doing a specific job by electronic means if it is possible to do the same job just as efficiently by purely mechanical methods, and no electronic engineer worthy of the name would dispute this, provided that the initial premise is proven. Nor is there any question at all that some jobs can be done electronically, and by no other means. In between these extremes, however, there lies a host of examples in which the controversy can be debated.

The advocates of the avoidance of electronic circuitry in equipment that is not fundamentally electronic have most frequently pointed the finger of scorn on the score that electronic equipment is fundamentally more subject to failure than purely mechanical or electrical gear, and there are many arguments which can be brought to bear both for and against this thesis. It is not our purpose to debate them here, for the most important fact is that such a ground for argument exists. Reliability must be achieved, and, in some cases, at all costs. Thus, if any room for doubt exists, it is little wonder if conservatism wins the day.

Since the war, however, it has been made increasingly apparent, even to completely non-technical people, that electronic equipment can not only perform wonders which were not even dreamed of a few short years ago, but, further, that these same wonders can be worked with great regularity and with a reliability which is as necessary in war as in peace-time application.

In spite of this, one American firm has recently announced the production of a special series of valves, whose outstanding feature is that they can be expected to have a useful life of at least ten thousand hours, and this under conditions of great rigour such as would give ordinary valves little chance of survival after a very short time.

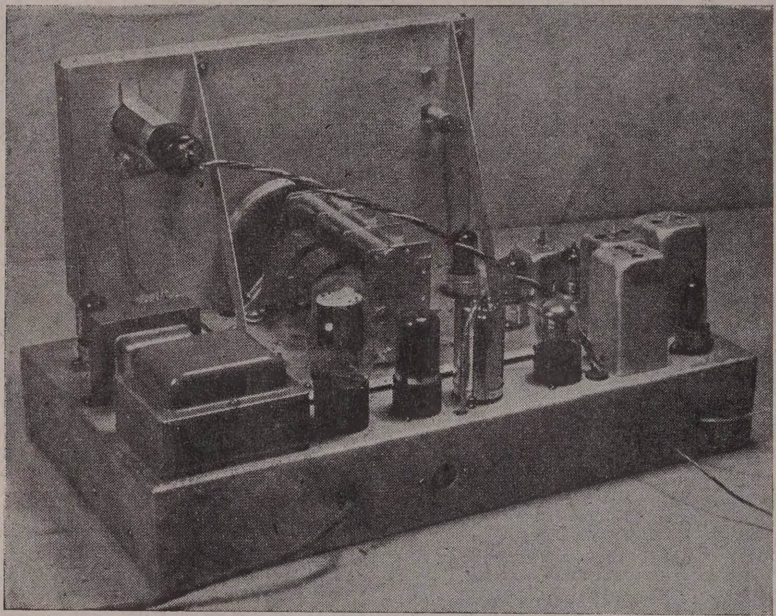
This is an extremely important and significant development, because it shows that one of the biggest and best-known valve manufacturers in the world is alive to the all-important factor of reliability in industrial applications, and, better than this, is doing something about it. With valves like this available, it should be only a matter of time before the sceptics are confounded and before electronic gear can confidently take the place in engineering practice which its own special advantages have long marked out for it.

So far, only three or four types of these special industrial valves have been announced, and it is noteworthy that each of them is an exact replica, electrically, of already well-known types of valve. It is clear that a great deal of intensive research and development must have gone into making these new valves possible, so that it is only to be expected that their prices are several times higher than those of their conventional counterparts. But for equipment which must not fail and where the breaking down of a single valve might do irreparable damage to plant valued at many thousands of pounds, or might even be the indirect cause of loss of life, a mere six or seven times the price of an ordinary receiving tube is a small enough premium!

It is by means of far-sighted development projects such as those which have resulted in the tubes we are discussing that electronic engineering can make genuine advances, which, though much less spectacular than the invention of television or radar, are none the less just as vital to a new and growing industry.

The "Rainbow" Communications Receiver

Readers have seen advertised in these pages for some time the "Rainbow" tuner, by S.O.S. Radio, Ltd., of Auckland. The receiver described here has been designed by "Radio and Electronics" in conjunction with S.O.S., with the object of showing how the "Rainbow" tuner can be made into an excellent communications set for amateur and shortwave listeners.



Back view of the completed receiver. A description of the placement of the various valves and transformers is given in the text, and an under-chassis photograph is to be found on page 6.

INTRODUCTION

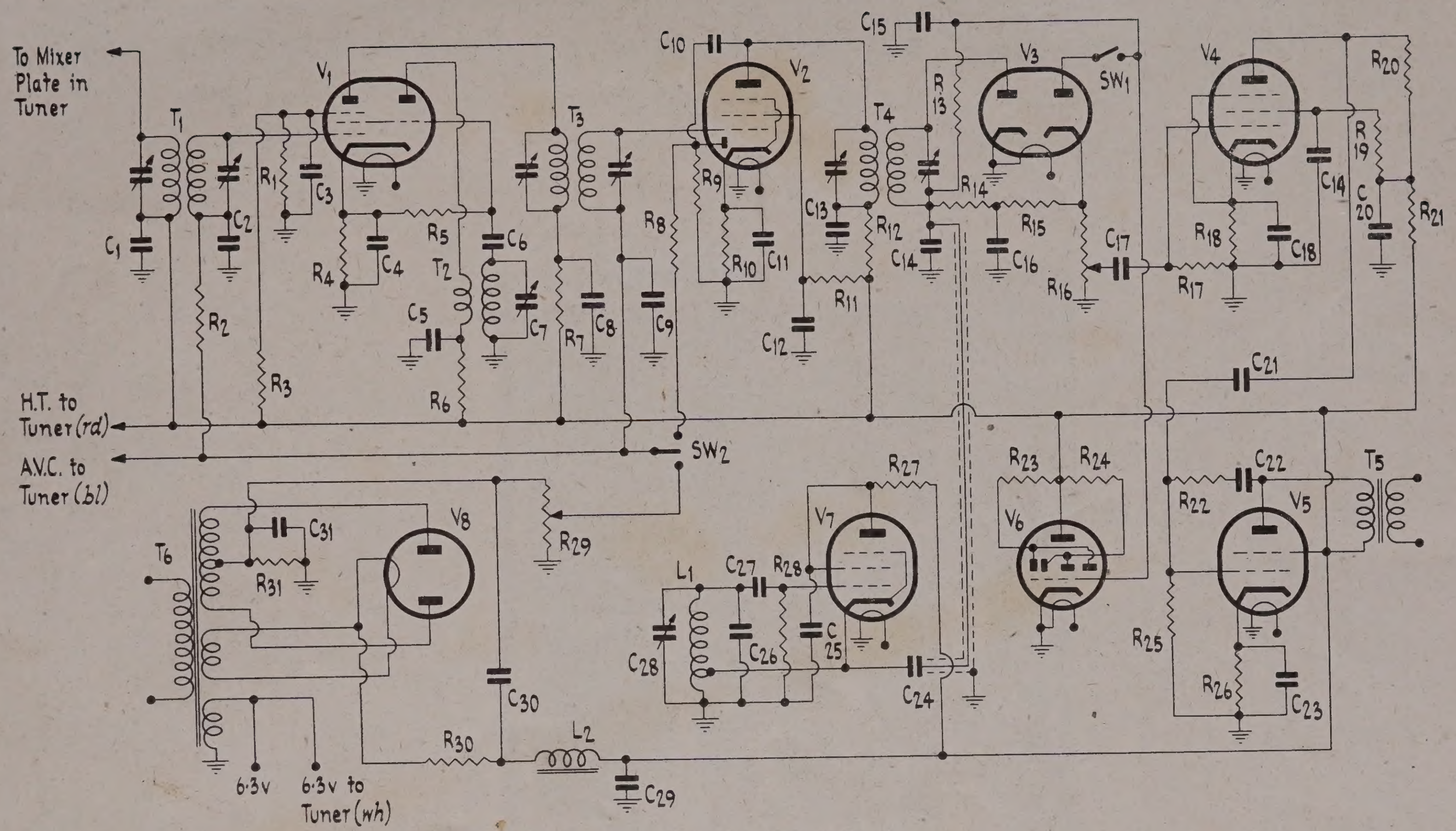
As readers are no doubt aware, it has always been the policy of "Radio and Electronics" to design the receivers, amplifiers, and so on which are presented as practical constructional articles from month to month. Further, we have made it a rule not to specify particular makes of components or assemblies. However, in this one instance, we are breaking this self-imposed rule, and have collaborated with Messrs. S.O.S. Radio Ltd., the retailers of the S.O.S. "Rainbow" tuner in the design of a communications receiver, which uses this tuner. The chassis has been specially designed to suit, and the whole receiver will be available in kit form.

Of course, there is no reason why the circuit should not be used to follow any tuning unit whose normal output frequency is in the region of 465 kc/sec., and there will be many who will no doubt wish to use the circuit, and some of the ideas in it, in building receivers with a different line-up or with another "front end."

SCHEME OF THE RECEIVER

The idea behind the design is this, that many of those whose interests are more towards the short-wave bands, because they are S.W. DX fans, or else because they are amateur transmitters, will want a set with at least partial bandspread, and with more selectivity than the normal set. These requirements are quite different, and need different solutions, but the first is solved in the present set by reason of the fact that the "Rainbow" tuner has complete bandspread on the 80m. amateur band, and partial bandspread on all the other bands that users are likely to be interested in. These include all the short-wave broadcasting bands, and the 40 and 20m. amateur bands. The second is taken care of in the design of the remainder of the set, and is obtained by using a double frequency-conversion, with 100 kc/sec. as the second intermediate frequency. This gives far more selectivity than can be obtained with a 465 kc/sec. I.F., without resorting to special circuits, and at least two stages of amplification. The set as a whole has the following features, all of which are particularly desirable in an amateur-constructed communications receiver.

(1) Very high sensitivity.
(2) A special bandspread control, giving fine tuning round about any frequency to which the main dial may be set. The degree of this extra bandspread is constant, irrespective of the signal frequency.
(3) The broadcast band is included, which is often desirable when the set has to do duty as an ordinary domestic set as well as a communications receiver.
(4) The selectivity is much better than that of the average receiver with a 465 kc/sec. I.F., and yet there are no multiple I.F. stages to make construction difficult or critical in any respect.
(5) The high gain (almost as great as that of a 465 I.F. set with two stages) ensures that even very weak short-wave stations give substantial deflection of the magic eye.
(6) A B.F.O. is included.
(7) Arrangements have been made for all non-standard coils to be commercially available.
(8) In spite of the high gain of the set, there will not be any difficulty about instability, since no



COMPONENT LIST

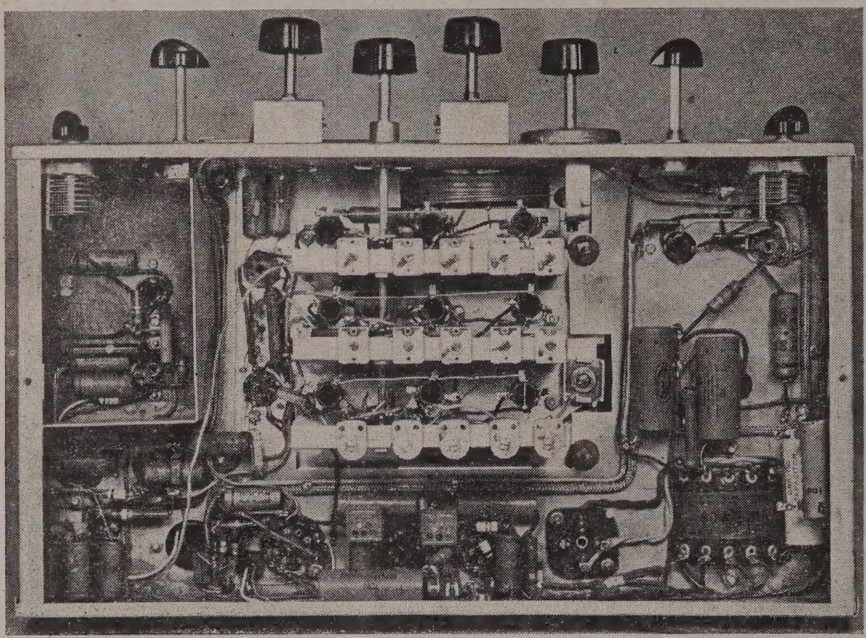
V_1, ECH41. V_2, EAF41.
V_3 6H6 or EB34. V_4, 6J7.
V_5, 6V6. V_6, EM34.
V_7, EF41. V_8, 80.
T_1, 455 kc/sec. I.F. transformer.
T_2, 355 kc/sec. osc. coil.
T_3, T_4, 100 kc/sec. I.F. transformers.
T_5, output transformer, 5000 ohms to V.C.
T_6, power transformer, 385v.-a-side, 80 ma.
L_1, 100 kc/sec. B.F.O. coil.
L_2, smoothing choke, 80 ma.
C_1, C_2, C_3, C_4, C_8, C_9, C_{11}, C_{12}, C_{13}, C_{19}, C_{22}, C_{25}, 0.05 μf. C_5, C_{15}, 0.02 μf.
C_6, C_{10}, C_{24}, C_{27}, 100 $\mu\mu$f.
C_7, 25 $\mu\mu$f. max. variable.
C_{14}, C_{16}, 250 $\mu\mu$f.
C_{17}, C_{21}, 0.001 μfd.
C_{18}, C_{23}, 25 μf. 25v. electro.
C_{20}, 8 μf. 450v. electro.
C_{26}, included in L_1.
C_{28}, 15 to 20 $\mu\mu$f. max. variable.
C_{29}, C_{30}, 16 μf. 450v. electro.
C_{31}, 50 μf. 50v. electro.
R_1, R_{14}, R_{21}, R_{27}, R_{28}, 50k.
R_2, R_{11}, 100k. R_3, 35k.
R_4, 200. R_5, 25k.
R_6, 30k. R_7, R_{12}, 2k.
R_8, R_9, R_{13}, R_{19}, R_{23}, R_{24}, 1 meg.
R_{10}, 300.
R_{15}, R_{20}, 250k.
R_{16}, 250k. pot.
R_{17}, R_{25}, 500k.
R_{18}, 1000.
R_{22}, 5 meg.
R_{26}, 250.
R_{29}, 25k. pot.
R_{30}, 1000 ohms, 10 watts.
R_{31}, 500.
Sw_1, S.P.S.T. noise lim. on/off.
Sw_2, S.P.D.T. A.V.C. on/off.

two stages are on the same frequency. This makes the set very easy to construct, even for the most inexperienced builder, who would almost certainly have difficulty in "sitting down" a set of comparable gain, without the double conversion principle.

(9) No trouble will be found from the reception of the harmonics of the second oscillator. This one has tended to scare many off from the use of the double superhet. principle, but there need be no fear of it in this case.

(10) While the quality of reproduction cannot be expected to be high in a set which is very selective, a quite pleasing balance has been achieved, and the set is by no means unpleasant to listen to on broadcast.

(11) Noise-limiter circuit.



VALVE LINE-UP

The "Rainbow" tuner consists of an oscillator-mixer, using one of the new Rimlock valves, the ECH41, preceded by another Rimlock, the EF41, as a tuned R.F. amplifier. All the coils and bandspread arrangements are included in the unit, and the whole is sold, complete with the two valves, and properly aligned. The I.F. with which the unit is intended to work is 455 kc/sec. Thus, our own construction starts at 455 kc/sec., and proceeds to a second oscillator-mixer stage, which converts the signal to 100 kc/sec. Here, there is a stage of amplification on this frequency, after which comes the final detector, audio amplifier, beat frequency oscillator, and magic eye tube. It can be seen, therefore, that all we have in addition to the I.F. stage is the second oscillator mixer, whose purpose is only to allow us to have our I.F. amplification on 100 kc/sec. instead of on 455 kc/sec. Of course, the second mixer gives useful amplification at the same time.

The second oscillator mixer is also an ECH41, both because this valve is an excellent performer, and because it then becomes interchangeable with the first oscillator-mixer valve, and reduces the number of tube types in the whole receiver. The next valve is the 100 kc/sec. I.F. amplifier, and is an EAF 41. This is a dual-purpose valve containing a remote cut-off pentode and a single diode in the same envelope.. Its diode is used as the A.V.C. rectifier. The detector and noise-limiter valve is a 6H6, and this is followed by a conventional audio section, comprising a 6J7, pentode-connected voltage amplifier, and a 6V6 power amplifier. The B.F.O. uses an EF41, connected as a triode. This valve then becomes interchangeable with the R.F. amplifier, which also uses an EF41. This is a remote cut-off R.F. pentode, similar to the one in the EAF41, but, as its type number suggests, it has no diode included in the construction. The magic eye tube is an EM34, which has two shadows, of different sensitivities, so that one is effective on weak signals, and the other is usable on strong signals. The sensitive shadow closes, and the less sensitive one with it, but after the former is closed, the latter continues to close, and does not shut up completely until a very strong local signal is tuned in.

THE CIRCUIT

Now, in spite of the use of double conversion, the circuits employed in the receiver are quite conventional, and offer no difficulties, either constructional or by way of alignment. The whole circuit, apart from the tuner itself, can be regarded as a fixed-tuned receiver for signal frequencies in the region of 455 kc/sec. In the normal set, the fixed-tuned receiver consists only of a stage of amplification, the I.F. amplifier, followed by the detector and audio stages. Here, however, the receiver is itself a superhet., with a mixer, oscillator, and I.F. of 100 kc/sec.

V_1 is the ECH41 second oscillator-mixer. It uses a cathode bias resistor to give it its minimum bias, and a voltage divider, as recommended by the manufacturers, for supplying the screen voltage. In the tuner, the output terminal is the plate pin of the first ECH41, so that the input of the rest of the set consists of a 455 kc/sec. I.F. transformer, T_1. Its primary is connected through to the H.T. line, on the one side, and directly to the plate of the first mixer on the other. Thus, the first mixer is supplied with plate voltage from T_1. In the tuner no wire is brought out from the ECH41 plate, and the wire lead from 455 I.F. transformer is used to make the connection. The oscillator section of V_1 on our circuit is quite normal, except that it uses a special coil, designed for an oscillation frequency of 355 kc/sec. This is the right frequency to beat with

(Continued on page 41.)

SOME APPLICATIONS OF THE 8012

In last month's issue of "Radio and Electronics" we printed characteristics and operating conditions for the 8012 V.H.F. transmitting tube. This month, since stocks have become available to amateurs through the sale of war-surplus tubes of this type, we are giving some circuits in which the 8012 has been put to use in our laboratory, and retailing some of our own experience with this versatile valve.

INTRODUCTION

Many amateurs are now operating on the high-frequency bands and are becoming interested in working some of the very high bands where practically no activity exists at the present time. One of the difficulties in working the V.H.F. bands has always been the acquisition of suitable valves, both for receiving and transmitting, but since the late war this situation has remedied itself to a very great extent. In the U.S.A., war-surplus material has enabled amateurs to become active even on the microwave ham bands, but here there has been a dearth of equipment of this sort. Nevertheless, there is now available (and not only from war stocks) a very fine range of valves that are entirely suitable for building receivers of good quality for bands at least as high as the 420 mc/sec. one, and, as far as transmitting is concerned, there seems to be no good reason why, with currently available valve types, all bands up to and including this one should not be operated.

A further difficulty from the amateur's point of view is that, not being very conversant, in many cases, with the techniques required at these frequencies, he is reluctant to spend much money or time on them with what appears to be slight prospect of success. To that end, therefore, we have prepared some circuits which use tubes that are available here to-day, and which are therefore applicable to local conditions. In overseas publications there is a great deal of material appearing at the present time, describing gear for the V.H.F. and U.H.F. bands, but much of it is of purely academic interest, since the components concerned are not generally available.

GENERAL CHARACTERISTICS OF THE 8012

Before going on to examine some actual circuits, it might be as well to have a look at the 8012 itself, and see if we can come to any conclusions regarding the type of circuit in which it can be expected to perform best. Because of its peculiar type of construction, the 8012 is specially well suited to circuits which use long lines as the tuning elements. This is not to say that it will not work well with conventional tuned circuits at frequencies for which these are suited, for a valve which is specially designed for V.H.F. use will perform at least as well as, and usually much better at medium and low frequencies than will ordinary valves whose frequency ratings are much more limited. Now the 8012 is rated as having a plate dissipation of 40 watts, in C.W. service, and 27 watts when used as a plate-modulated Class C amplifier. These ratings hold up to a frequency of 500 mc/sec., and the tube can be operated at reduced ratings as high as 600 mc/sec. The 812-A, on the other hand, is rated at 45 watts plate dissipation (CCS) on C.W., and at 30 watts (CCS) with plate modulation. This tube can be operated at these ratings up to only 30 mc/sec., and at reduced ratings up to 100 mc/sec. From this comparison alone, which

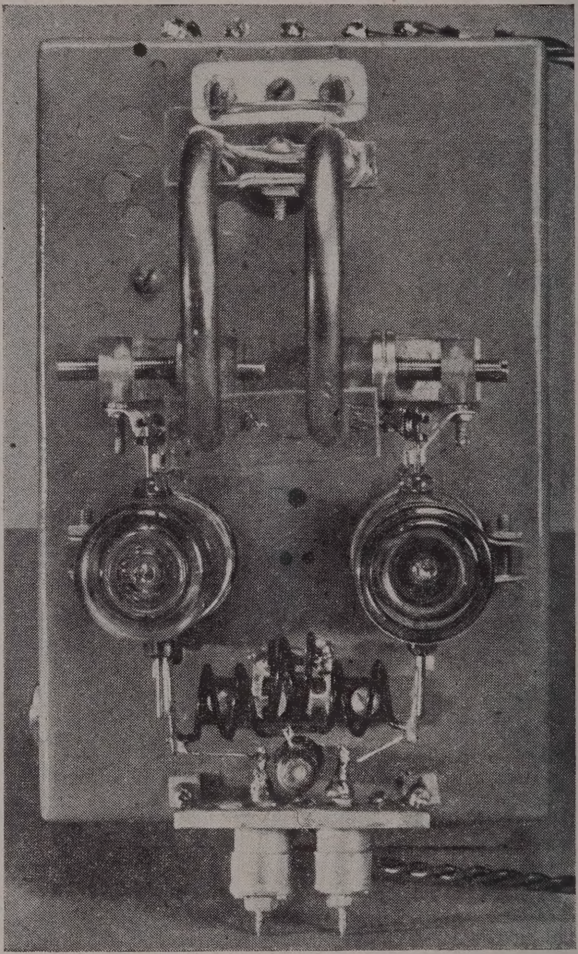


Fig. 2.—Plan view of the amplifier.

shows that below their respective limit frequencies for full ratings, the 8012 and 812-A are very similar in respect of plate dissipation, it can be inferred that better performance could be expected at 30 mc/sec. from an 8012 than from an 812-A. Thus, there is a definite advantage in using V.H.F. transmitting tubes at the high end of the H.F. band, even though they were designed for much higher frequencies still. It would clearly be far better to use a V.H.F. tube at frequencies well within its frequency limits than to use another tube at reduced ratings, near the upper limit of its allowable frequency band. In other words, and taking a concrete example, if a medium-powered final amplifier is to be designed which is to

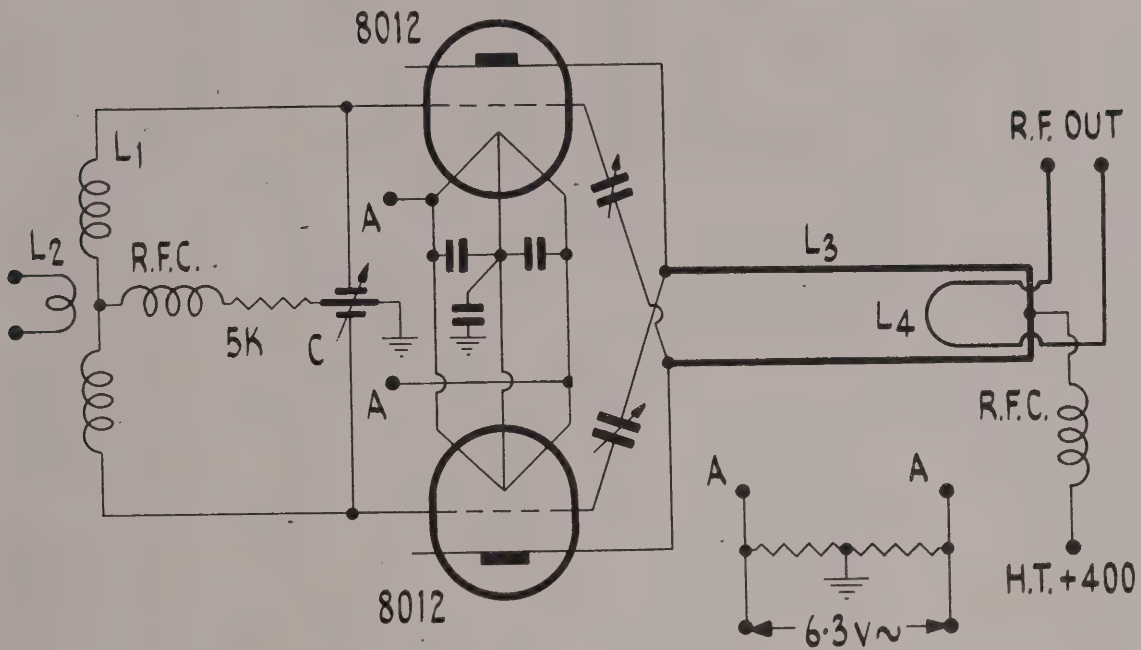


Fig. 1.—Circuit of the 144 mc/sec. amplifier.

be capable of working efficiently on the 144 mc/sec. band as the highest frequency in which the builder is interested, it is perfectly practical to design the stage round a V.H.F. tube (or pair of them) rather than using tubes which can only be run without modification to the plate supply voltage, etc., up to the 30 mc/sec. band, and then building an entirely separate power stage solely for use on 144 mc/sec.

The physical arrangement of the grid and plate leads of the 8012 is quite suitable for use with ordinary LC tuned circuits, especially where a pair of the tubes is to be used in push-pull and, at the same time enables line-controlled oscillators or amplifiers to be constructed very readily. Our front cover this month shows a push-pull Class C amplifier for the 144 mc/sec. grids and a parallel line circuit as the plate tank. An examination of the two photographs of this amplifier shows how beautifully symmetrical the circuit arrangement can be made, and a glance at the circuit diagram shows that there is nothing unusual about it at all. The ordinary cross-neutralizing circuit is used with conspicuous success, and, although the neutralizing adjustment is perhaps a little more critical than usual to adjust, the correct adjustment, once found, will hold excellently, and an amplifier results that is as stable in operation as any well-constructed push-pull stage for the lower frequencies.

It is rather doubtful, to say the least, whether such a neutralized amplifier could be built successfully, without a great deal of trouble, if conventional tubes were used.

THE 144 mc/sec. NEUTRALIZED AMPLIFIER

Though it would no doubt be possible to build a neutralized Class C amplifier with a single 8012, such a stage would almost certainly be more difficult to neutralize, and would probably have to use one of the lesser-known neutralizing schemes which do not find much use in amateur circles simply because they require adjustment every time the working frequency is altered. For this reason, it was decided to make the stage a push-pull one. Under normal circumstances, any tube of comparable plate dissipation would be much more costly than are the currently available 8012's, and this tube itself would be far more expensive than similarly rated low-frequency valves. However, on account of the low price at which they are available, it was decided that the purchase of two would not unduly strain the amateur pocket-book, and that the push-pull version would not therefore put too many people off on grounds of expense. In addition, those who are wanting to build a separate final for 144 only will find that the outlay is very little more than that for the tubes themselves, since there are no expensive tuning condensers to buy and because the stage will work very well and deliver more watts to an aerial than somewhat, with only 400 volts on the plates. At the same time, there will be no difficulty in working the tubes up to their full ratings if one possesses a power supply of from 750 to 1000 volts at 100 ma. or so. One of the beauties of V.H.F. work is that, given suitable tubes, the circuitry is usually easy to make one's self from a few pieces of copper or brass rod and/or tube, together with a few pieces of heavy copper wire. The circuit of the amplifier is shown in Fig. 1. The grid current is conventional. Coupling from the driver is obtained from a two-turn link, L_2, which is centrally placed with respect to the two halves of the grid coil, L_1. This is made from 18-gauge wire, and consists of four turns, two on each side of the central gap, which makes room for the coupling link. The turns are ½ in. in diameter and are spaced ¼ in. apart. The gap between the halves of the coil is ¾ in. wide. The link, L_2, is made

of the same wire, wound to ½ in. diameter also and spaced by ¼ in. It is mounted on a strip of insulating material which carries two solder lugs, and which is supported about ⅛ in. from the top of the chassis. The construction of the grid circuit should be quite clear from Fig. 2, which is a plan view, taken from directly above. The tuning condenser C has been shown on the diagram as a split-stator, but in practice a dual Philips trimmer was used. In this case, the small U-section support becomes the common stator connection, and the photographs show how it was mounted, by soldering it to two small bolts which are run through the chassis. Between the two rotor connections, in Fig. 2, can be seen the end of the small R.F. choke in the grid circuit. This is soldered to the centre of L_1 and passed through a hole which is large enough to allow about 1/16 in. clearance between it and the edge. Underneath, the other end is terminated on an insulated solder lug, which also forms a terminal for one end of the grid resistor of 5k.

The purpose of using a dual Philips trimmer instead of a split-stator condenser is twofold. In the first place, it is considerably cheaper, and, secondly, but more important still, it enables a trick to be done that cannot readily be employed when the more usual style of component is used. However symmetrical one may make the circuit, it is inevitable that unbalances will occur in the stray capacities. At very high frequencies, these unbalances result in unequal driving voltages and therefore in unequal plate dissipations and output powers in the two sides of the push-pull circuit. But if some means exists of equalizing the drive to the two tubes, one can at least ensure that one valve is not carrying more load than the other. In some cases it might be difficult to see whether this desirable state of affairs has been reached, but with the 8012's it is a simple matter, because they are designed to run with the plates red. Now, with two separate condensers in the grid circuit, it is possible not only to tune the circuit to resonance, but also to achieve any desired degree of balance or unbalance in the voltages fed to the two halves of the amplifier. To do this, it is only necessary to make a small adjustment to one of the condensers, and then restore the circuit to resonance with the other. Thus, in operation, the drive is adjusted by this means until the circuit is in resonance, and at the same time the plates of the tube are judged to be the same colour, and therefore to have the same temperature. If the stage is being run at such a low level that neither plate shows any colour, then balancing in this way does not matter very much, as long as any unbalance is not great enough to affect the neutralization or the power output. It will be found that of the infinitely large number of possible adjustments in which the circuit is at resonance, there will be one which gives the greatest combined grid current. This is the correct one to adjust for when the tubes are running lightly enough not to show any colour.

The plate tank circuit is an open-wire line made from ¼ in. brass or copper rod. The rods are cut to a length of about 11 in., and are bent simultaneously so that the bends will be in exactly the same place on each. The bend is 1⅝ in. in diameter, and starts 4⅜ in. from one end of the rods. This brings one end of the rods approximately ¾ in. higher than the other, so that the plate ends of the rods can be about level with the plate pins of the valves after mounting as shown in the photograph. The lower ends of the rods are fixed together by means of a small piece of sheet brass, 1⅜ in. x ¼ in., in such a way that they are spaced by ¾ in., centre to centre, and are parallel throughout their length. Two spacers are made from perspex and slipped on via the open end of the line, preferably before the shorting bar is soldered on. This makes a rigid structure, which can be supported solely by means of a stand-off

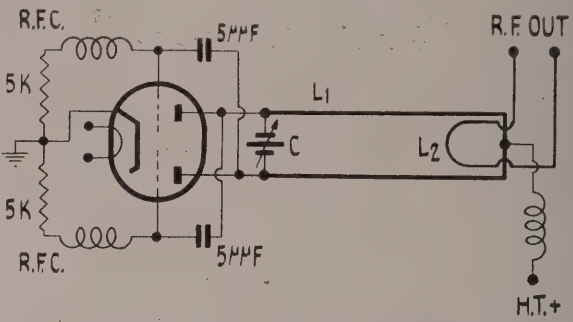


Fig. 3.—Suitable oscillator for driving the 8012 amplifier at plate voltages below 400. The plate lines are made of 5/32 in. brass rod, are spaced ¼ in. between centres, and are 10½ in. long. The tuning condenser C is a home-made split-stator with one fixed plate attached to each rod, and the rotor floating. Capacity is approximately 5 µµf. The oscillator voltage should be 250.

or feed-through insulator to which the centre of the shorting bar is screwed. At the open, or plate, ends of the line two short pieces of copper braid, ¾ in. long, are soldered, making flexible connections for the plate pins of the valve. The ends of the bits of braid are fitted with small clips. These can be seen in the photograph, and were made by soldering together two of the fork-like connecting lugs from an Amphenol-type of moulded bakelite valve socket. Similar clips can be used for the four connections that have to be made to the two grids. It should be pointed out for the benefit of those who have not seen the valve, or the diagram of it printed in our last issue, that there are two pins each for the grid and plate of each valve. These come out perpendicularly to the sides of the cylindrical glass envelope, and the top ones are the plate connections, while the lower ones are the grid connections. On the grid circuit side of the valves, the grid pins are used as connections for the tuned circuit, while on the plate circuit side, the other two grid pins are used as points of attachment for the neutralizing condensers. The plate pins on the grid circuit side of the tubes are unused. The plate sides of the neutralizing condensers are wired to the ends of the plate lines, and not directly to the plate pins. The reason for this is that doing so shortens the leads from the neutralizing condensers, and at the same time it make the required neutralizing capacity slightly larger than the actual grid-plate capacity of the valves themselves. The method of wiring in the neutralizing condensers is actually indicated on the circuit diagram, where the thick lines represent the rods of the plate tank circuit.

In order to tune the plate circuit, an adjustable

shorting bar is constructed. This can be seen in the photograph, pushed down as far as it will go towards the fixed shorting bar on the end of the lines. In this position, the frequency was exactly 144 mc/sec., which is the lowest one of the band. The plan view also shows the construction used for the movable shorting bar, which is made from $\frac{1}{4}$ in. wide pieces of copper sheet, bent to fit the curvature of the rods, and so that they are only about 1/16 in. apart between the rods. They are clamped in position by means of a small screw, working into a nut which is soldered to one of the pieces.

The chassis used was a small one, 6 in. x 4 in. x 2 in. It will be seen that the Philips trimmers used in the grid circuit extend a little over the end of the chassis, so that, if desired, the latter could be made an inch or so longer at the grid end, if this was thought desirable. The valves are a little difficult to deal with on account of the fact that they have no plug-in bases, but this was overcome quite simply. The valves are almost exactly one inch in diameter, so that a regulation 1 1/8 in. valve hole serves admirably for them. To mount them, two bands are made, $\frac{3}{8}$ in. wide, which will go almost all the way round the tubes, and which can be tightened by means of a small nut and bolt. This fixing can be seen in the photographs. The bands are fixed to the chassis by soldering two bolts to each and passing the bolts, which have had their heads cut off, through small holes in the chassis, right at the edge of the 1 1/8 in. valve holes. They are then fixed by screwing on nuts into the bolts, until their bottom rims are level with the chassis, after which the bands are tightened with their nuts and bolts. It is a good plan to place a ring of paper between the valves and the mounting rings, because the glass envelopes get quite hot in use, and the paper acts as a heat insulator and mechanical buffer, helping to prevent breakage of the glass owing to expansion. In the original, no trouble of this sort was encountered.

The construction of the neutralizing condensers can be seen quite well from the photographs also. They are made from brass discs, 9/16 in. in diameter, and soldered to $\frac{1}{8}$ in. diameter brass rods. They are mounted on pieces of perspex $\frac{3}{4}$ in. x $\frac{1}{2}$ in. x $\frac{1}{4}$ in. thick, which in turn are mounted on pieces of brass plate, 1 in. x $\frac{1}{2}$ in. In our case, the rod holding the outside plate in each case was threaded, and so was the hole in the perspex into which the rod went, but it would be quite satisfactory if the rods were made a driving fit into the holes in the perspex, thus avoiding the necessity for having them threaded. In this case pieces of braid can be soldered on to the movable plate, or on to its mounting rod, and used to connect it to the grid pins with a clip similar to the ones already described, for connecting the plate lines to their pins.

FILAMENT CONNECTIONS

Particular note should be taken of the way in which the filaments of the 8012's are connected. There are three filament leads for each tube, and their purpose is to reduce the inductance of the filament circuit so that this can be more effectively earthed when the tube is working at very high frequencies. The third lead goes to a centre-tap, **which is to be used only as an R.F. ground return connection and not as the D.C. ground return for the plate current.** The manufacturers do not state the reason for this prohibition, but presumably it is due to the fact that the point on the filament where the centre-tap joins on would overheat if this were done. The circuit diagram shows the proper way in which the filaments should be connected, both for R.F. and for the D.C. plate current. The filament bypass condensers are 25 $\mu\mu$f. silvered mica ones, as small physically as can be obtained. There will be no good done by using larger condensers here, as they would tend to increase the inductance in the filament circuit instead of reducing it, thus defeating their own purpose. Two of them serve to connect all three leads in parallel, as far as R.F. is concerned, while the third, which is connected from the centre-tap leads to earth, effectively earths the whole system as far as R.F. voltage is concerned. The D.C. plate current cannot flow through this connection, so that the filament supply is also centre-tapped by a pair of small resistors. Their value has not been specified on the diagram, but this was done purposely, since the values can vary according to what is wanted. For example, if one is going to use grid-leak bias only, for which condition the 5k. grid leak is correct, then the resistors should be low in value, because if they are large, they will develop extra bias over and above what is supplied by the grid leak. However, if partial cathode bias is wanted, as protection in case of failure of the excitation, it would be possible to increase the value of these resistors until the D.C. drop through them gave the desired amount of cathode bias, under conditions of no drive. It would be possible to make them 2000 ohms each, giving an

(Continued on page 37.)

The "Radio and Electronics" Abstract Service

AUDIO EQUIPMENT AND DESIGN:

Recording and reproduction of sound. Part 21. Various methods of audio frequency correction for specific applications.
—**Radio News (U.S.A.), November, 1948, p. 50.**

Why must we have bad audio? Methods of improving fidelity of audio stage of receivers, particularly for the cheaper variety of receiver. Substitution of better-quality loudspeakers, addition of negative feedback, and other suggestions.
—**Radio News (U.S.A.), January, 1949, p. 43.**

ANTENNAE AND TRANSMISSION LINES:

Transmission-line filters. Graphs of pass and attenuating bands of several types of transmission-line filters. Three general types of filter sections considered. Discussion limited to filters using transmission-line of negligible dissipation and having small spacing compared with wavelength. Formulae derived.
—**Wireless Engineer (Eng.), January, 1949, p. 11.**

Aircraft antennae. Using charts to determine reactance and resistance of fore and aft, trailing, vertical, centre-fed V and off-centre-fed V aircraft antennae. Series of charts provided for the purpose. Worked examples of application.
—**Communications (U.S.A.), November, 1948, p. 22. (Continued December, 1948, p. 28.)**

CIRCUITS AND CIRCUIT ELEMENTS:

Novel controlled rectifier. Power supply with variable output. Circuit using one valve for rectifier and control purposes. (See "Radio and Electronics" Abstracts, April, 1949.) Experiments severally with types 6AS7, 1625 (12v. 807), and 6L6 valves. Tabulation of ranges of output from each type.
—**Radio News (U.S.A.), November, 1948, p. 44.**

Some notes on the Clapp oscillator. Details of experiments with this circuit. Type 12AU7 (or 6SN7) valve used, one triode section as oscillator, other diode section as cathode follower. Hints for guidance of constructors.
—**QST (U.S.A.), January, 1949, p. 45.**

FREQUENCY MODULATION:

Phase discriminator for F.M. reception. Circuit and details of operation of a phase discriminator which, it is claimed, provides larger output voltage and which is easier to align.
—**Electronic Engineering (Eng.), January, 1949, p. 25.**

A precision F.M. sweep generator. Circuit and construction of a unit for which unusual stability is claimed. Coverage 3-23 and 87-109.7 mc., For servicing TV equipment.
—**Radio News (U.S.A.), January, 1949, p. 52.**

INDUSTRIAL APPLICATION:

The Drimeter. Particulars of an automatic moisture control unit used in connection with the manufacture of textiles. Fabric is passed through two plates arranged as a capacitor, and unit makes continuous measurements of dielectric constant of the material. Modulated R.F. applied to an R.F. bridge system, balanced with no material between the plates. Unbalanced current produced by the introduction of fabric as dielectric is amplified and demodulated, then applied to meter calibrated to show moisture content. An automatic control unit makes appropriate adjustments to the drying machine.
—**Electronic Engineering (Eng.), January, 1949, p. 10.**

Customs installations. Suggestions for design of "custom built" units for housing radio, radiogram, TV receiver—either one or more. Proposed as a sales feature.
—**Radio News (U.S.A.), January, 1949, p. 35.**

MICROWAVE TECHNIQUES:

Laterally-displaced slot in rectangular waveguide. Calculation of power radiated by slots cut in rectangular wave-guides, and of phase of radiation by application of transmission-line theory. Details of corroborative experiments.
—**Wireless Engineer (Eng.), January, 1949, p. 3.**

A novel microwave-measuring technique. Describes adaptation of principles governing operation of Michelson's interferometer to measurement of wavelength and frequency of microwaves. Details of construction of unit.
—**QST (U.S.A.), December, 1948, p. 26.**

MEASUREMENTS AND TEST GEAR:

Simplified resistance calculations. (1) Operating chart for resistors; (2) calculating parallel resistance.—Nomogram.
—**Electronic Engineering (Eng.), January, 1949, p. 17.**

Direct-reading impedance meter. Use of system of comparison as with ohmmeter, for resistance measurement) to obtain impedance measurement. Comparative impedance within unit comprises a network, impedance of which may be held constant while its phase is varied to correspond with that of impedance to be measured. Circuit and details of unit capable of giving readings within approximately 2 per cent. accuracy over impedance range from 0.2 ohm to 0.2 megohm, with phase variations from minus 63 degrees to plus 63 degrees.
—**(Electronic Engineering (Eng.), January, 1949, p. 22.**

A compact distortion meter. Details of test unit to assist in servicing audio amplifiers by giving direct readings of distortion percentage. Employs 1N34 crystal diode. No valves, power supply, or batteries required.
—**Radio News (U.S.A.), November, 1948, p. 68.**

PROPAGATION:

Propagation and antennae above 50 mc. Analysis of possibilities of 50 and 144 mc. bands at times when no abnormal conditions exist. Intended as a guide to amateur operators.
—**QST (U.S.A.), January, 1949, p. 24.**

Making the higher frequencies pay off. Antenna characteristics discussed, with reference to V.H.F. and higher frequencies. A discussion to assist the amateur operator to an understanding of antenna design for these frequencies.
—**QST (U.S.A.), January, 1949, p. 25.**

RECEPTION AND RECEIVERS:

A compact superhet. tuner. Circuit and construction of a small superheterodyne receiver for use with headphones. Uses 12AT7 dual-wave triode valve as oscillator and converter, respectively; 6AK5 as I.F. amplifier, one triode section of second 12AT7 as second-detector and other triode as B.F.O.
—**Radio News (U.S.A.), November, 1948, p. 52.**

New trends in receiver design. Part 4. Elimination of record scratch in radiograms. Description of two methods employed by U.S. manufacturers, using a capacitative reactance valve. Advantage taken of operation of Miller effect in a valve having a pure resistance as a plate load to achieve a suppression of scratch level when no high frequencies present. Duo-diode-triode valve (6AQ6) used as reactance valve.
—**Radio News (U.S.A.), November, 1948, p. 54.**

Build your own communications receiver; Part 4. R.F. tuner sections. Circuit and construction of separate tuners for 75, 40, 20, and 10 meter (amateur) bands.
—**Radio News (U.S.A.), November, 1948, p. 59.**

. . . Details of construction of a 2-metre converter for use with the communications receiver the subject of this series of articles.—**Radio News (U.S.A.), January, 1949, p. 66.**

A.C.-D.C. receiver for A.M. and F.M. Particulars of a receiver using new type miniature (US.) valves. Circuit details.
—**Radio News (U.S.A.), November, 1948, p. 62.**

W3KPX high-gain pre-amplifier for 10 metres. Uses high-Q, iron-core R.F. coils; plate circuit tuning in output stage. NAG5 type valves employed. Constructional details.
—**Radio News (U.S.A.), January, 1949, p. 49.**

New life for old receivers. Circuit and construction of separate crystal-controlled converters for 14, 21, and 28 mc. (amateur) bands. Crystals required: for 14 mc., 6,000 kc. triples; for 21 mc., 5875 kc. (triples), and for 28 mc., 12,250 kc. (doubles). Valves employed are 6AK5, neutralized and triode-connected, as R.F. amplifier, 6J6 as crystal oscillator-multiplier, 6AK5 as mixer, and 6C4 cathode follower output.
—**QST (U.S.A.), December, 1948, p. 16.**

TELEVISION:

Using sweep generator with TV receivers. Description of techniques in using sweep generators in servicing TV receivers.
—**Radio News (U.S.A.), November, 1948, p. 46.**

Modern television receivers; Part 8. Coupling networks in TV receivers. Aligning video I.F. stages. U.S. manufacturers' practice.—**Radio News (U.S.A.), November, 1948, p. 70.**

. . . . Part 10. Description of different types of A.G.C. systems in current use by U.S. manufacturers.
—**Radio News (U.S.A.), January, 1949, p. 60.**

Simple pre-amplifier for boosting TV signal strength. Circuit and construction of small one-valve unit which may be used with indoor aerial for increasing strength of TV signals at receiver.—**Radio News (U.S.A.), January, 1949, p. 57.**

TRANSMISSION AND TRANSMITTERS:

Screen-grid modulation. Circuit details and construction of a high-level, screen-grid modulator. Single 6V6 valve will fully modulate a 250-watt carrier. Uses 6SJ7 and 6J5 valves in speech amplifier. In transmitter, described, the output valve is an 813.—**Radio News (U.S.A.), November, 1948, p. 41.**

Low-cost mobile station; Part 1. Details of construction of a converter for high-frequency (amateur) bands, in particular 11-metre band, and intended for use with broadcast-type car receiver. Employs 6BE6 converter valve and OB2 voltage regulator for power supply.
—**Radio News (U.S.A.), November, 1948, p. 42.**

Building a series-tuned V.F.O. unit. A highly stable substitute for 3.5 and 7 mc. crystals. Designed to incorporate the series-tuned Colpitts circuit in the oscillator section. Has 6AG7 oscillator, 6L6 output stage. Output from unit sufficient to drive p.p. 807 valves.
—**QST (U.S.A.), December, 1948, p. 11.**

V.H.F. man's V.F.O. A unit is described which has a degree of frequency stability sufficient for high-order frequency multiplication and combines speech amplifier and reactance modulator for N.F.M. Oscillator is 6AG7 in Clapp circuit, with 6AG7 amplifier. Output frequency is 6.75 to 9 mc. in 4 ranges, calibrated. for multiplying into 11, 10, 6, and 2-metre (amateur) bands. Method of oscillator calibration described. Circuit details.—**QST (U.S.A.), December, 1948, p. 23.**

Jungle job—100 watts. Circuit and details of construction of

a compact portable transmitter for 3.5, 7, 14, and 28 mc. (amateur) bands. 6V6 tritet oscillator, 815 output. Blocked-grid keying.—**QST (U.S.A.), December, 1948, p. 39.**

Mobile in miniature. Constructional details of a 10-metre mobile transmitter. Dynamotor power supply. Employs tube 6C4 valve as 7 mc. oscillator, crystal-controlled; 6C4 doublers and 2E24 output. 6AQ5 valves as modulators. Slug-tuned coils.

—**QST (U.S.A.), December, 1948, p. 44.**

The basic phone exciter. Circuit details of a single-sideband exciter, with provision for P.M. and double-sided A.M., all selectable by use of a three-position switch. Full constructional details.—**QST (U.S.A.), January, 1949, p. 11.**

80 and 40 on wheels. A mobile transmitter which is suitable for emergency or portable use. Output, 20 watts. Operates from either car battery or mains. Unit construction. Full details of circuits and construction.

—**QST (U.S.A.), January, 1949, p. 18.**

A door-knob oscillator for 420 mc. 50-watt oscillator, using type 316A (VT 191) or 703A "Doorknob" type valves.

—**QST (U.S.A.), January, 1949, p. 29.**

Versatile low-power phone-C.W. transmitter. Simple unit for amateur bands from 3.5 to 50 mc. using crystals in 3.5 to 9 m.c. range. Comprises 6AG7 harmonic, crystal, oscillator, and 2E26 type valve as amplifier. 6L6 modulator. Circuit and details of construction.—**QST (U.S.A.), January, 1949, p. 38.**

VALVES:

Inter-electrode capacitance of valves. Change with operating conditions. Details of measurements made of grid-cathode and grid-anode capacitance at frequency of 1 mc. Valves used in tests were type DET22 and E1714.

—**Wireless Engineer (Eng.), January, 1949, p. 26.**

MISCELLANEOUS:

Adaptiug Webster record-changers for microgroove recordings. Details of method of changing Webster-Chicago (U.S.) models 50, 56, and 70 for new long-playing records.

—**Radio News (U.S.A.), November, 1948, p. 39.**

Electronic measurement and control of heat. (Part I of a series of three articles.) Heat control methods discussed. Circuits of high-precision temperature control system; temperature recorder; electronic thermometer; constant temperature oven and other devices.

—**Electronic Engineering (Eng.), January, 1949, p. 13.**

Radiation from car-ignition systems. Description of measurements made with wide-band (2.5 mc.) receiver of field strength of radiation from typical car-ignition system. Receiver covered 20-30 and 40-650 mc. ranges. Conclusions summarized.

—**Wireless Engineer (Eng.), January, 1949, p. 31.**

An inexpensive ladder-type mast. Constructional details of a mast approximately 30 feet in height, suitable for supporting a 20-metre beam antenna.

—**Radio News (U.S.A.), November, 1948, p. 57.**

An Electronic Switch—Two Pictures at Once on the Same Cathode-Ray Tube

Sometimes it is a very real advantage to be able to display two waveforms at once on the screen of an oscilloscope. This electronic switch enables this to be done without the aid of a special cathode-ray tube. In addition, it provides separate gain controls and input terminals for the two input voltages, so that the size of each picture can be independently controlled.

WHAT THE ELECTRONIC SWITCH CAN DO

In some types of work it is absolutely necessary to observe two waveforms simultaneously, and usually this is better done on one oscilloscope tube rather than on two separate ones. In other work, the same facility may not be compulsory, but can be highly desirable, as well as instructive. The obvious example of the first type of work is that of examining the waveforms in equipment where all are not

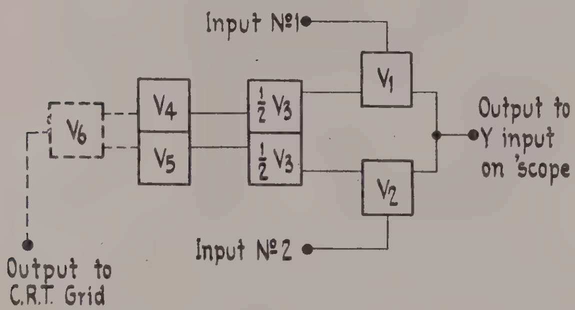


Fig. 1. Block diagram of the switch

sine-waves. All pulse-forming circuits come under this heading, and a simple case is that of the common or garden time-base circuit, whether it uses hard valves or a gas triode. For demonstrating the time-relationship between any two waveforms, an oscilloscope which can throw both of them on the one screen, with the same time-base for each, cannot be beaten. With an electronic switch like the one we are about to describe, the traces on which the two waveforms are displayed can be superimposed or they can be separated. When the traces are superimposed and then only one waveform is applied, the horizontal sweeps on which the other voltage would appear draw a line across the screen, just like an unused time-base, and this line shows the position of the datum-line for the waveform that is being examined.

Not all of us are interested in radar, or pulse modulation, or television, which are the three fields where a switch like this would find its greatest use, but, even so, it forms an interesting adjunct to any 'scope, and can be used with advantage even where we are dealing with more ordinary circuits, such as audio amplifiers. As an educational instrument, the oscilloscope can have greatly increased usefulness if it is used in conjunction with an electronic switch, as it can be used to demonstrate such things as the relative phases of two sine-waves and the phase relationships that occur in all circuits which handle alternating current, of whatever frequency, within the response of the amplifiers incorporated in the unit.

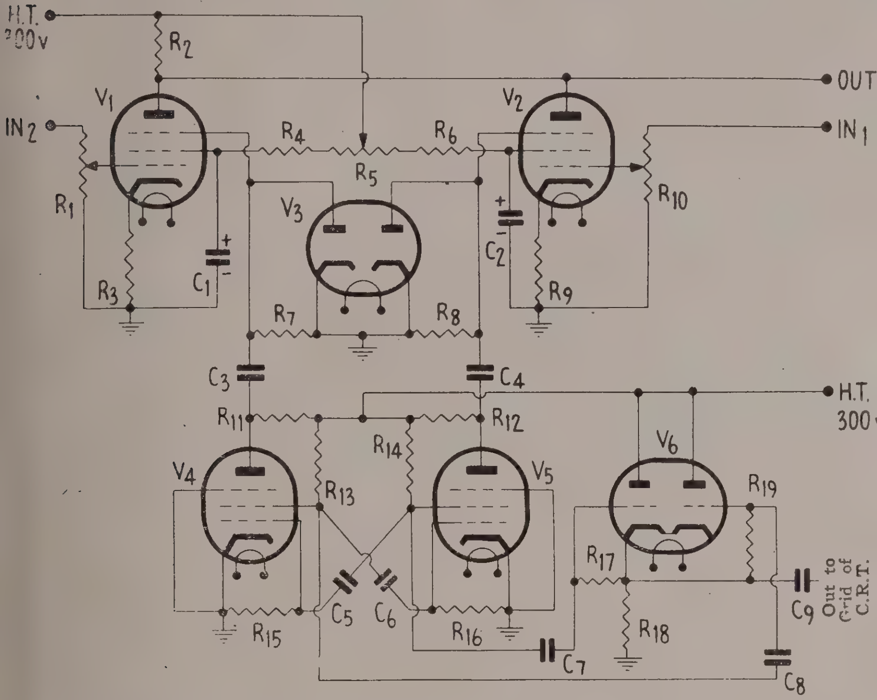
HOW IT WORKS

Briefly, the principle of the switch is as follows: Each input voltage is applied to the grid of a separate amplifier tube, and is amplified in a straightforward manner. The outputs of the two amplifiers are connected in parallel, so that, without any switching, all that would happen would be the addition of the two waveforms into a composite one; if this were done, and the result shown on the 'scope, it would be impossible to tell which part of the picture belonged to which input voltage, and if by chance the waveforms happened to be of the same frequency and had almost the same shape, it would be impossible to tell by inspection that there were two sgnals present in any case. In order to avoid this situation, we proceed to switch the two amplifiers on and off, in such a way that while one is on the other is off, and vice versa. If we do this at a rate that is much slower than the frequency of the waves we are examining—i.e., the input voltages—then during each switching period there will be time for several cycles of the signal voltage to occur.

To sum up, let us take a numerical example. Suppose that the two waveforms we are to examine have a frequency of 1000 kc/sec., and that the switching is being done at a rate of 25 times a second. Each amplifier will be switched alternately on and off for periods of one-fiftieth of a second. During the "on" period of each amplifier, its signal will have gone through 20 cycles, so that if we can find some means of supplying a time-base on the 'scope, and this can be done simply by putting the time-base saw-tooth on the X plates in the ordinary way, then the two waveforms will appear on the C.R.T. each independently of the other. The persistence of vision that is so useful in making moving pictures and television possible will see to it that we get the impression of a continuous double picture, whereas, in reality, only one waveform is being shown at a time.

It might not be immediately apparent why the one time-base, applied to the X plates of the 'scope without any switching, can serve for both waveforms, but a litle further consideration of what is happening will make this clear. With the time-base operating, the sequence of events is as follows. Suppose that the signal and switching frequencies are 1000 and 25 c/sec. respectively, as before, and that the time-base is running at 250 c/sec. Starting at the point where amplifier No. 1 is switched on, the time-base, running at 250 c/sec., performs five complete sweeps, at the end of which time, amplifier No. 1 is switched off and No. 2 is switched on. During this time, the signal has gone through 20 complete cycles, so that on each time-base sweep four cycles of the signal appear. The five sweeps of the time base are superimposed, just as in a normal 'scope's picture, and so, for the one-fiftieth of a second during which

amplifier No. 1 is on, amplifier No. 2 is inactive, and we have on the screen a normal presentation of a single waveform. Almost instantaneously, now, amplifier No. 1 goes off and No. 2 comes on. Then for the next one-fiftieth of a second we have a further five time-base sweeps and a display of four cycles of the voltage applied to amplifier No. 2. Since we have done nothing to change the time-base, its sweeps occur in exactly the same place as they did before, while No. 1 amplifier was on, so that the waveform now being shown occupies the same place on the C.R.T. as did the previous one. This completes the cycle of events, since at the end of this one-fiftieth-second period the switch again reverses



the positions of the amplifiers, and the whole process repeats itself.

HOW IS ALL THIS DONE?

In the above description, we have not said anything about how the things which were described are brought about, except that the unit contains two amplifiers and a switch mechanism of some sort. In Fig. 1 we have a block diagram of the complete unit. V_1 and V_2 are the two amplifiers. The block diagram is intended to indicate that these valves have their plate circuits connected in parallel, and that the single output terminal so formed is fed into the Y-input terminal of the oscilloscope. V_3 is a double diode, whose purpose is not fundamental to the operation of the unit, so that we will leave it out of consideration for a moment. V_4 and V_5 form the actual electronic switch. They are pentodes, and are connected in a multivibrator circuit and produce suitable switching waveforms. These are applied, through the halves of V_3, to the suppressors of V_1 and V_2, and cause the suppressors to be either at earth potential, when the valve acts in the usual way as an amplifier, or sufficiently negative to cut off the plate current altogether, in which case it gives no output.

THE CIRCUIT IN DETAIL

The complete circuit, except for power supply, is shown in Fig. 2. The power supply requirements are 300 volts at approximately 20 ma., and no special considerations apply, so that it has been left off the circuit. V_1 and V_2 are 6SJ7's. Their grid circuits, cathode circuits, and screen circuits are quite separate, and the only point in common is the plate. There is here a common plate load resistor of 250k., for which the cathode and screen resistors are chosen as if only one tube were present. The reason is, of course, that, owing to the switching action, only one of the tubes is "on" at a time, so that, from the point of view of choosing the circuit values, the other can be regarded as absent altogether. The cathode resistors are left unbypassed, and doing so reduces the amplifiers' gain appreciably. This is of very little consequence, however, since most 'scopes have amplifiers in any case, and that provided by the amplifiers in the switch unit is additional. However, if desired, it is possible to feed the Y-plate directly from the output of the switch unit, even in the case of a 5 in. C.R.T. There are really two unusual things about the amplifiers and their circuit, and these are (1) the use of very large bypass condensers at the screen terminals and (2) the connections to the suppressor-grids. A further feature that is perhaps unusual is the potentiometer, R_5, whose purpose has not yet been stated. As can be seen, this control enables both valves to be given exactly the same screen voltage or can be adjusted so that one valve has a higher screen voltage than the other. It can be called a Trace Separation Control, and should be brought out to the front panel. It enables the two pictures either to be superimposed or to be separated in either direction. How, will be described later.

The suppressors, instead of being directly connected to the cathodes of their respective valves as usually is the case, are coupled to the plates of V_4 and V_5 through C_3 and C_4. R_7 and R_8 form "grid leaks" for the suppressors. The connections of the diodes are very simple, one being shunted across each suppressor leak resistor.

COMPONENT LIST

V_1, V_2, V_4, V_5, 6SJ7.	V_3, 6H6.	V_6, 6N7.
R_1, R_5, R_{10}, 1 meg. pot.	R_2, 250k.	R_3, R_9, 1000.
R_4, R_6, R_{15}, R_{16}, R_{17}, R_{19}, 1 meg.		R_7, R_8, 10 meg.
R_{11}, R_{12}, R_{13}, R_{14}, 50k.	R_{18}, 25k.	C_1, C_2, 8 μf. 450.
C_3, C_4, 0.5,	C_5, C_6, C_9, 0.01.	C_7, C_8, 50 $\mu\mu$f,

The switching multivibrator is of the pentode type, which has been described previously in these pages, and in particular was used as the basis of an extremely linear time-base which was described in the April, 1948 issue of "Radio and Electronics." Briefly, it consists of two "triodes," which are the cathode, screen, and control grid of each valve. These form the basic multivibrator circuit, as the screen of each valve is coupled via a condenser to the grid of the other. This causes the arrangement to oscillate at a frequency determined by the sizes of the grid leaks and coupling condensers, this frequency being the switching frequency. The oscillation of any multivibrator does not produce anything even remotely resembling a sine-wave, and it is because of this very fact that it is so useful as an electronic switch. The output of the multivibrator is a very fine square wave, or, rather, two such square waves—one from each plate, and, as might be expected from the symmetrical nature of the circuit, these outputs are in anti-phase to each other.

In order to help readers to obtain a full understanding of the working of the unit, Fig. 3 has been prepared, showing the most important waveforms throughout the circuit. At (a) and (b) are shown the waveforms at the plates of V_4 and V_5. It will be seen that the plate current is either cut off altogether, in which case the actual plate voltage is that of the H.T. line, or has a definite value which is limited by the circuit values. These waveforms illustrate the voltages in the circuit, and in each case reference points are given. It can be seen that the waves from the plates of V_4 and V_5 are identical in shape, but that when one is at its positive peak, the other is at the negative one. and vice versa. The amplitude of each square-wave is about 100 volts. That is to say, when the valve is conducting, its plate voltage is plus 200, and when it is cut off the plate voltage is plus 300. Next, in Fig. 3 (c) and (d), we have the shape of the waves that are applied to the suppressors of V_1 and V_2. It will be noted that the shape is exactly the same as at the plates of V_4 and V_5, but that, since the wave in each case has been passed through a condenser, the voltage reference point has altered. In Figs. 3 (c) and (d), it is imagined that V_3 has been removed. The large coupling condensers, C_3 and C_4, in conjunction with the high grid leaks, R_7 and R_8, see to it that there is no attenuation of the square waves, so that, as well as their shapes being unchanged, their amplitudes are also the same as at the plates of V_4 and V_5. Now, the purpose of a blocking condenser is to let alternating voltages through, but to block off any D.C. voltages which may be present. Because of this, the square waves go from — 50v. to + 50v., about earth potential as the datum or reference voltage.

This is not very convenient, because we do not want the suppressors of V_1 and V_2 to go to 50 volts positive during the "on" period. If this were allowed to happen, the valves would certainly not be working as normal amplifiers when they were switched on. What we want is for the valves to be cut off, by a large negative suppressor voltage, and then to be turned on by the suppressors returning to earth potential, which is where they should be for normal amplifier operation. It is for this reason that the diodes of V_3 have been included in the circuit. Fig. 3 (e) and (f) show what happens when V_3 is plugged in. We still have our square waves of 100v. amplitude, but in each case the voltage excursions are from earth potential to — 100v. This is the condition we want, and by using the diodes we have assured ourselves that the suppressors of V_1 and V_2 cannot go positive, however large the amplitude of the square-wave we feed in from the multivibrator valves.

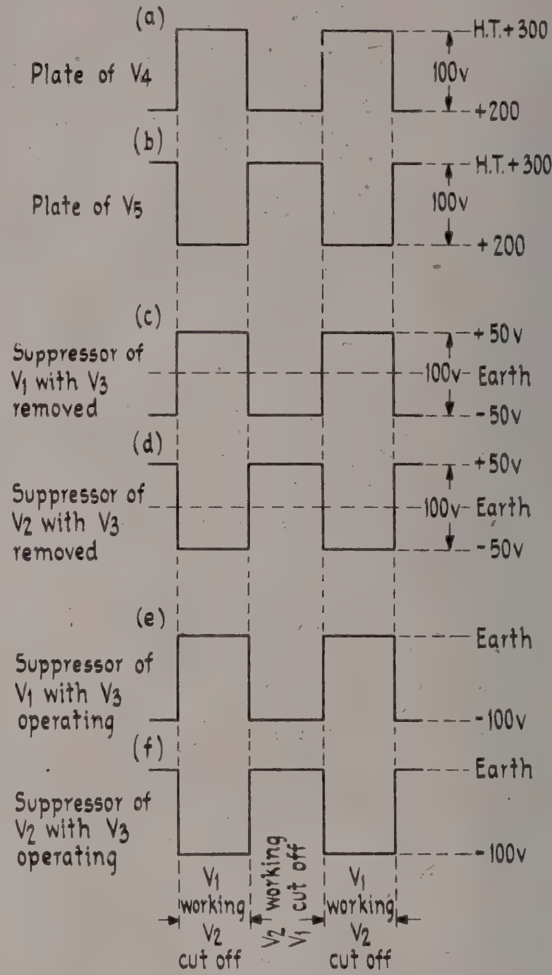


Fig. 3. Some important waveforms

The diodes in this application are called **D.C. restorers.** What they have done is to re-insert a D.C. component into the waveform, the original one having been lost when the blocking condensers were interposed. It would have done us no good to omit the blocking condensers and retain the original D.C. component, because this was not of the correct polarity or voltage. Briefly, the action of the D.C. restorer is as follows. On the first positive half-cycle that comes along, the diode conducts, and because it is connected with its cathode to earth, a negative voltage is built up across the leak resistor. This negative voltage partially charges the coupling condenser, and before this charge can leak away, the next positive half-cycle has come along and caused further grid current to flow, thus building up a further negative charge on the coupling condenser. After a few cycles, the blocking condenser is charged

(Continued on page 33.)

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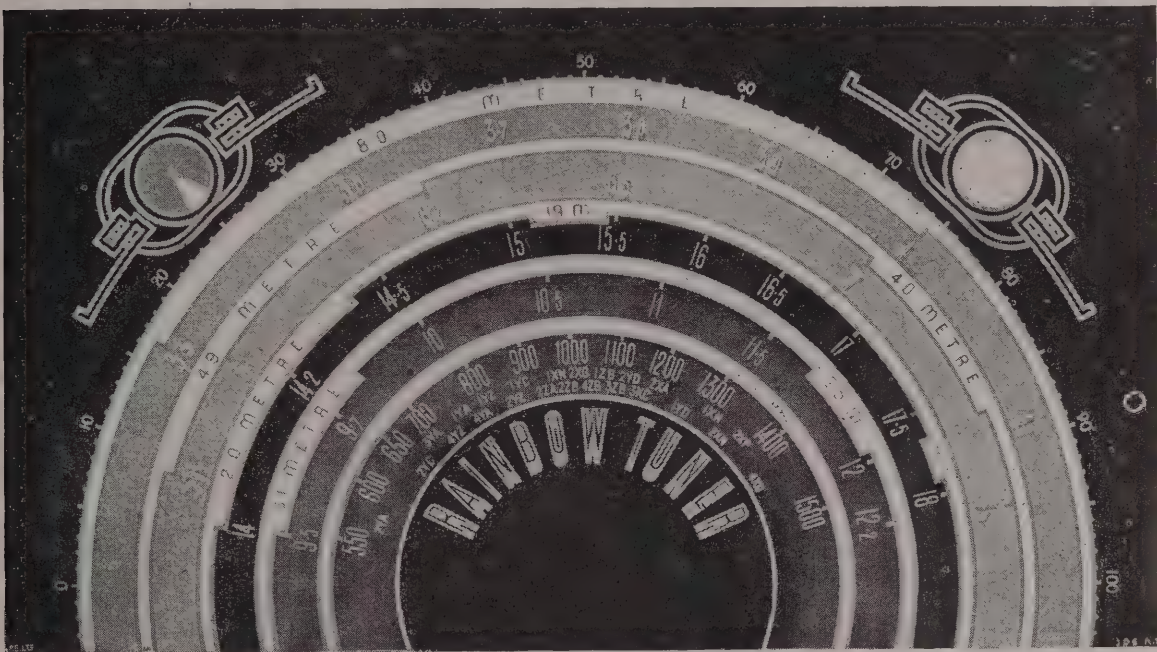

The above is a photo of the S.O.S. RAINBOW DIAL, reduced to quarter-size, its overall dimensions being 12 in. x 6½ in. The basic colour of dark blue is surmounted with five rainbow colours, with a different colour to distinguish each band, and all the figures, lettering, and divisions are photo-etched into the glass in gold, giving the dial a very attractive appearance. The band colours are: Broadcast, red; 25 to 31 metres, yellow; 16 to 20 metres, green; 40 to 49 metres, blue; and 80 metres, violet; thees translucent colours being indicated by the false magic eye on the left when the wave-change switch is rotated. On the right, provision is made for a dual sensitivity magic eye. In addition, to facilitate logging of stations, a scale of 0 to 100 is provided.

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QUESTIONS and ANSWERS

MODIFICATIONS TO "JUNIOR COMMUNICATIONS RECEIVER"

M.L., Belfast, writes asking some questions about proposed modifications to the "Junior Communications Receiver," which was described in recent issues of "Radio and Electronics." He wants to know (1) if there are any strong objections to using 2.8 mc/sec. for the first I.F. and 200 kc/sec. for the second I.F. in this receiver, and (2) whether, since the coils he has for these frequencies, which are all single-tuned circuits, each in their own shield can, can be coupled together by means of a small condenser from the plate of the valve to the grid of the next, in all cases.

First of all, we should state that there are no grave objections to altering the intermediate frequencies in a receiver like this one, and that, other things being equal, a higher first I.F. than the original should be advantageous rather than anything, as it will increase the image rejection. In this set, which has no R.F. stage, the image rejection relies almost entirely on the highness of the first I.F. As for raising the second I.F. to 200 kc/sec., this may decrease the selectivity somewhat, but as long as the tuned circuits have a high Q, the loss in selectivity may not be very great.

Since the "transformers" are not transformers at all, but separate tuned circuits, some scheme whereby a pair of them can be included between the mixers and I.F. tubes and between the latter and the next mixer or the diode detector will be absolutely necessary. The method of coupling suggested by M.L. is quite all right, but is not so good as the bottom-capacity-coupling method. The reason for this is that the latter method makes the connection between the two tuned circuits a low-impedance one, whereas the top-capacity method suggested by our correspondent gives a high-impedance coupling, with its attendant high I.F. voltage on the connection. Also, it is far more critical to adjust, whereas the bottom-capacity method is not at all critical in a case like this. The method consists in placing a large condenser attached across each coil. The coupling is then made by joining with a wire the two junctions between the large and small condensers. This system is the basis of the variable selectivity tuner which was described some months ago in these pages (October and November, 1948, issues). The coupling between the circuits is **less** the greater the series condensers that are inserted, and all that needs to be done to alter the coupling is to make quite large changes in the value of these components, after which the windings are all re-tuned to resonance. As long as the coupling condensers are large enough to make the coupling of the windings less than critical, there will be no double peaks in the resonance curves, and the coupling can be made considerably less than critical, which will give rather more selectivity at the expense of some gain. In the receiver under consideration, however, there is, if anything, too much overall amplification, so that nothing at all would be lost by coupling the circuits for a maximum selectivity.

THE CATHODE-FOLOWER OUTPUT STAGE

"Hi.-Fi.," of Christchurch, writes enclosing a circuit from one of our Australian contemporaries, and asks if we would give our comments and impressions in the "Question and Answer" column. This we are very pleased to do, since the subject is one which has not been presented in our own pages, but which has been dealt with in some detail a year or two back in overseas publications. The circuit is for a single-ended output stage, using a 6V6, which is connected as a cathode follower. The primary of the speaker transformer is connected between the lower end of the cathode-bias resistor (bypassed in the usual way) and earth. The plate of the 6V6 is connected directly to H.T., and in order that the valve may still act as a pentode, the screen is fed from a dropping resistor and decoupled to the cathode with an 8 μf. electrolytic condenser. The voltage amplifier is a 6J7, R-C coupled to the output stage.

Many claims have been made for a cathode follower output stage of this kind. These are (1) excellent speaker damping, owing to the very low impedance seen by the primary of the output transformer when looking back into the cathode terminal of the valve; (2) very low distortion in the output stage, due to the 100 per cent. negative feedback; (3) very wide frequency response, unaffected by the rise in the voice-coil impedance at high and low frequencies; (4) inexpensive adaptation of an existing conventional output stage. To some extent these claims appear to be justified, but whether a cathode follower output stage is any better than a normal output stage which has plenty of feedback round it in the ordinary way is somewhat problematical. In the first place, just as effective speaker damping is obtained with the normal negative feedback stage. It can be shown that after a gain-reduction of three or four times has been achieved, any improvement of the damping that is obtained by adding greater degrees of feedback is very slight indeed. Secondly, although it is true that any stage which has 100 per cent. negative feedback, as in a cathode follower, the distortion is negligible, it is not possible to consider only one stage of an amplifier, but consideration has to be taken of what the effects, if any, of converting the output stage on the driver.

Now, it is well known that the cathode follower has a voltage gain of less than unity, although it produces power amplification. This means that a cathode follower output stage must be supplied with an input signal voltage equal to—and in practice a little greater than—the output signal voltage. Now, in a cathode follower output stage, the output transformer must have the same turns ratio in order to match the speaker to the load as it has when the normal plate connection is used. Thus, in a 6V6 output stage, whether cathode follower or not, the R.M.S. output voltage for full power output is 150 volts. Thus, if the stage is to give its full 4.5 watts output, as quoted in the valve manuals for plate and screen voltages of 250, the signal input voltage to its grid will have to be $150/0.9 = 167$v. R.M.S. This is equal to 234v. peak. Now, it would be possible to supply this from a high-quality inter-stage transformer with a step-up ratio of, say, 3:1, thus necessitating a peak signal voltage from the driver of 78 volts. This is within the capabilities of the average small voltage amplifier triode, but by doing this we have lost our economy altogether, since a transformer of the high-fidelity variety would be very costly and would be the only kind worth putting in. How, then, would we get on with resistance coupling?

The solution used in the circuit sent by "Hi.-Fi."

is to employ a pentode amplifier, making its output voltage higher by taking its H.T. directly from the rectifier filament, through an extra smoothing filter of its own. Also, the screen voltage on the 6V6 is reduced to approximately 150 volts, at which the power output is drastically reduced—actually to about 2 watts. This means a reduction in the necessary signal input voltage to the 6V6, and therefore lightens the output requirement on the driving valve. The sum total of the above argument is this: That without transformer coupling it is not at all easy to get the necessary input voltage to make the power tube deliver its full output, and that resistance coupling can be used only at the expense of forgoing some of the output power of which the output stage should be capable.

The cathode follower output stage itself should certainly have a very extended frequency response, but unless an expensive output transformer is substituted for the ordinary one supplied with the speaker, there cannot be any marked benefit from this.

All in all, although at first sight the idea of using a cathode follower output stage looks quite attractive, it is by no means all it is often cracked up to be, and certainly does not make a royal road to high-fidelity, as some articles, not too well informed, have claimed for it. To our knowledge, the only road towards high fidelity is one of good design (which is hard work) and costly high-quality components (which are hard on the pocket), although a number of things can be done to make the most of existing equipment which is not all one might desire it to be.

SOME OSCILLOSCOPE PROBLEMS

R.T.W., Levin, has a number of questions regarding the two 5 in. oscilloscope designs that have been published in "Radio and Electronics":

(1) Whether to build what is essentially the May, 1946, model, but modified to include the multivibrator time-base, the switched input attenuators, and shift circuits of the 1948 model.

(2) Or to build the 1948 model in its entirety, but adapting the lay-out to suit the chassis of the original and to include the phase-inverter for the blackout waveform.

These are difficult things to advise anyone on, since the original model of the 'scope and the 1948 one are really quite different in design. There is, however, no reason why the amplifiers of one should not be used together with the time-base circuit of the other, nor is there any reason why an attempt should not be made to adapt the later version, which was built in two units, to the mechanical design of the former one, which was conventional in that it had a single cabinet enclosing everything. The latter would be a difficult job, because the second model was designed with the express purpose that all amplifier inputs and outputs should be brought out to terminals, to facilitate cross connection in a variety of ways, and so that the user would not be tied down to a 'scope in which the amplifiers were permanently connected to the deflecting system of the C.R.T., whether or not they were wanted. The ideal is certainly to have everything in one cabinet, but at the same time to have access to the input and output

of all amplifiers and the time-base, so that any combination of amplifiers can be used, with or without the time-base, and so that the C.R.T. itself can be used without either amplifiers or time-base, if this should be necessary. However, such a design is not easy, particularly when one wants to observe all the necessary precautions of short input and output leads, short connections between stages, and the rest.

Perhaps a practicable scheme would be that suggested by R.T.W. himself—namely, that of putting the output terminals of the amplifiers as well as the input terminals of the deflecting plates, on the back of the instrument. Then, short connections are possible, both for direct connection to the deflecting plates, and for inter-connection between them and the amplifier outputs. Then, the amplifier input terminals, gain controls, and attenuators would be on the front panel, together with the synch. input terminal and the time-base output terminal.

Another question brought up by our correspondent is whether or not it is advisable to use an R.F. power supply for the C.R.T. The chief advantage of this is that no high-voltage power transformer is necessary. Our correspondent is incorrect in stating that no high-voltage smoothing condensers are needed either. Clearly, the voltage rating of these does not depend at all on the manner in which the high-voltage D.C. is manufactured, but only on the D.C. voltage one ends up with. The CAPACITY of these condensers is much reduced by operating the rectifier from R.F., since the frequency is so high that only very small smoothing condensers are needed to remove all R.F. from the D.C. output. A high-voltage rectifier is still necessary also, and unless one has one of those specially designed so that the filament can be lit by the R.F. output of the oscillator, it is necessary to use a rectifier circuit in which the cathode is at earth potential, so that a high shunt capacity will not be placed across the output tuned circuit of the R.F. oscillator. This means that only the C.R.T. heater winding needs to be insulated for the full rating of the power supply voltage. Since there is now only one low-frequency power transformer in the whole 'scope, there should be less chance of unwanted magnetic deflection of the spot through stray 50 c/sec. fields from the transformer.

FREQUENCY FOR A MINE-DETECTOR

O.M., of Palmerston North, has an unusual problem for us regarding the operating frequency for a land-mine detector. This sort of thing has obvious applications to peace-time pursuits, such as the tracking of underground pipes and wiring, and we do not necessarily hold the view that O.M. has some uncharted land-mines in his district. However, his query is this: What frequency should it use? His difficulty is that he has, from an American publication, full details of a detector, operating on the following principle. The search coil is part of the circuit of an oscillator which works at some frequency higher than audibility. There is a second oscillator which, under normal conditions, is adjusted to zero beat with the first one. The output of each is fed to a common detector, and should anything happen to change the frequency of one of the oscillators, the difference frequency shows up as a howl in the headphones, which are energized by a two-stage audio amplifier following the detector. All that the magazine concerned fails to state is the frequency of operation of the two oscillators, since the coils are supposed to be purchased from an American mail-order house. The question is, can we advise as to what a suitable frequency would be?

Well, we have no first-hand knowledge of mine detectors, except that the latest ones do not use this principle, to the best of our knowledge. One way of tackling the problem is to make the oscillators' frequency as low as possible without including any ferrous material in the search coil. This makes for a certain amount of difficulty if one tries to go too low, since a great many turns are needed to reach, say, 20 kc/sec. without using some sort of iron-core material. The lower the frequency, the higher will be the effect on the frequency when some ferrous material comes into the field of the search coil. At the same time, since the detection is done by observing the beat note between the two oscillators, the higher the operating frequency the greater will be the beat frequency caused by a given percentage change in the "variable" oscillator. There must therefore be an optimum operating frequency, but since we have had no practical experience with such things, we are unable to say what this will be. It is suggested, however, that a suitable trial frequency would be in the region of 100 kc/sec., since there will be no

(Continued on page 48.)

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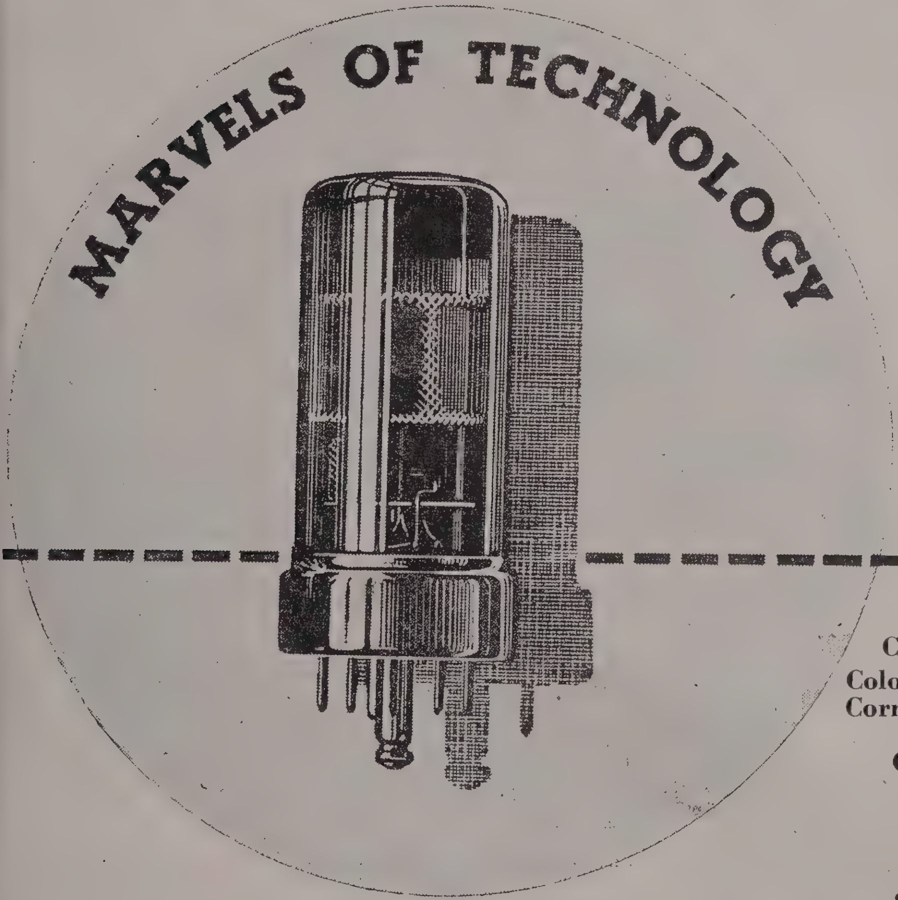

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PART 31

SOME MORE COMPLEX VALVES

So far, the only valves we have had dealings with are triodes and diodes, which you will remember have three and two elements respectively. We have had a brief look, too, at indirectly heated valves, which have a heater and a cathode instead of combining both functions in a filament, as do directly heated valves. In one way, it could be said that a valve which has a heater, a cathode, and a plate could be said to have three elements, and there might be some justification for calling it a triode, but custom has decided that such a valve shall be called an indirectly heated diode, and not a triode, which would confuse it with a directly heated triode. In short, when deciding to call a valve a diode or a triode, the heater, if any, is left out of the count in order to avoid confusion. Thus, an indirectly heated triode, which has a heater, cathode, plate, and grid, is still called a triode, and not by a name which means that it has four electrodes. This is quite reasonable, really, because the heater has no **electrical** connection with the remainder of the valve's circuit. It is only an extra piece whose purpose is to make the cathode able to "do its stuff" by emitting electrons. This brings up the question, "Are there valves with more than three elements, and, if so, what are they called?" Anyone who has even glanced at modern radio books will be able to say straight away that there are such things, and that some of them have as many as eight elements. We do not want to have anything to do with these at the moment, though their time will come, but what we are going to talk about are valves which have four and five electrodes. Now, if you are still at the stage where a circuit using a three-element valve looks quite complicated enough, it might seem reasonable to suppose that the circuits of these new valves would be much more so, but even before we start, it can be said that the extra complexity is very slight, as we will see as soon as we come to look at some circuits for them.

TETRODES AND PENTODES

In line with the names for diodes and triodes, valves with four and five electrodes are called TETRODES and PENTODES, respectively. In Fig. 44 we have illustrations of the symbols used in circuit diagrams for directly and indirectly heated tetrodes. These show that these valves are very similar to triodes, and that the only difference is that between the cathode and the plate are to be found two grids instead of only one. When we have a valve like this, it becomes necessary to distinguish between the grids, so that we can always tell which is meant. This is done by calling the one nearest the cathode the **control grid**, and that nearest the plate the **screen grid**. Sometimes they are called grids Nos. 1 and 2, but this is more often done when there are three or more grids, when they are numbered, starting with the one nearest the cathode, and working towards the plate.

In these tetrodes, the grid nearest the cathode can be looked upon as corresponding to the grid in a triode, the screen-grid being the extra one, put in for purposes which we will try to explain in a moment. This way of looking at the valve helps us to understand it, and the way it works, because it is always the grid nearest the cathode which has the signal voltage applied to it. This is why it, and not the second grid, can be said to correspond to the grid of a triode.

Now, it is a little misleading to talk about the **control** grid and the **screen** grid, because this might indicate that the latter does not control what goes on inside the valve, this being the sole responsibility of the control grid. Of course, this is not true, since in this case there would be no point in having the

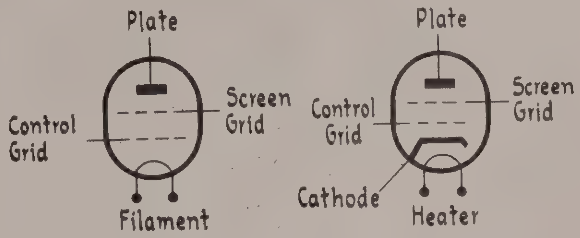


Fig. 44

screen grid there at all! The term **control grid** is simply a convenient way of indicating which one has the signal fed to it. Very often the word control is omitted, and the control grid is referred to simply as the **grid.** When this is done, we can assume that it is the first, or control, grid that is meant.

Because of its extra grid, a screen-grid valve has to have one more pin on the base, so that the connection to the screen grid can be made. Thus, a directly heated tetrode, or screen-grid valve, has five connections—two for the filament and one each for the grid, screen grid, and plate. An indirectly heated tetrode has six connections, since there must be one extra for the cathode. There is just one more point about the naming of the parts of the tetrode that we need to know, and that is that the screen grid is often called the **screen** for short. The most commonly used names for the elements of this kind of valve are thus the plate, screen, and grid, because these are shorter to write and say than anode, screen grid, and control grid.

WHAT IS THE TETRODE FOR?

At this stage we have described the elements of the four-electrode valve, and have learned a little about the various names by which they are called. We are now in a position to go on and see what this new type of valve is for, and what it can do that a triode cannot. In order to do this, we will first have to look a little more closely at the structure of the tetrode.

The diagrams shown in Fig. 44 gives a rough idea of the construction of the valve, just as does the symbol we have become so used to for the triode. In the latter, you will remember, the grid consists of a fairly fine wire mesh, or spiral, placed between the filament, or cathode, and the plate. The structure of the grid is quite open in most triodes, for, although its purpose is to control the way in which the elec-

trons from the cathode (or filament) reach the plate, it must be able to let electrons through its own structure. Now, the screen grid is also made up of a wire spiral, of larger diameter than that of the grid, and this is supported between the grid and the plate. In general, the screen-grid spiral is much more open than that of the grid, so that the flow of electrons, which is still controlled as to its density by the grid, can reach the plate without further obstruction. It will be remembered that the grid is almost always worked at a slightly negative potential with respect to the cathode, and that in operation the signal applied to it makes it more or less negative, thereby allowing less or more plate current to flow. Now the screen grid is always given a positive voltage, like the plate, and in the ordinary course of events, it is made somewhat less positive than the plate is. Now, since the electrons are always attracted by a positive potential, the effect of the screen grid is to make them go faster on their way to the plate than they would have done were the screen omitted from the valve. Also, because the screen-grid spiral is so open, the screen does not obstruct the flow of electrons to the plate.

As an example, one type of screen-grid valve which was very much used some years ago normally worked with 250 volts on the plate and 100 volts on the screen. Naturally enough, some of the electrons must hit the screen wires on their way to the plate, and the ones which hit the screen never reach the plate at all. However, this does not matter very much, except that it means that some current must flow in the screen circuit. This is only to be expected, and it is because the current drawn by the screen serves no useful purpose that the spacing of the screen wires is made as wide as possible. This causes the screen to intercept as few electrons as possible, thereby reducing the screen current to a small fraction of the plate current. In most screen-grid valves, the screen current is about a quarter to a fifth of the plate current. In a typical case, the plate current might be 10 ma. or so, and the screen current 2 ma.

We still have not answered the original question, what is the screen grid for? To do this, we shall have to have a further look at the behaviour of a triode, and see what there is about it that needs improving.

A TROUBLE WITH TRIODES

In the sets which we have built so far, we have used triodes as detectors and as audio amplifiers, and in both these cases they have been found to perform admirably, but there is one purpose for which we need a valve amplifier very much and for which the triode valve is not very suitable. So far, we have not built any sets in which the R.F. aerial currents are amplified before being detected, either by a crystal detector, a diode, or a triode. Now, there are one or two very great advantages in being able to amplify the very feeble radio frequency aerial currents before detecting them. Chief among these is that doing so will enable us to receive much weaker signals than can be done by detecting first and then amplifying the audio frequency output of the detector. The main reason for this is that detectors are more efficient if they have a reasonably sized signal to work with, and except for very close and powerful local stations, the size of the signal presented to the detector by the aerial can hardly be called anything but very weak indeed. For example, in modern sets that the manufacturers make, the detector does not come until quite a long way along the chain of valves, and by this time the signal for the detector can be measured in volts, so great has been the amplification AHEAD of the detector. The signal that the detector receives in one of our crystal sets, in which the detector follows the aerial immediately after a little amplification has been done by the tuned circuit, is only to be measured in thousandths, and even in millionths, of a volt, so it is easily seen what great advantages there are in amplifying the signal first, before detecting it.

A valve which is used to amplify the R.F. currents or voltages without detecting them is called a radio frequency amplifier, or, more briefly, an R.F. amplifier. Now, long ago, the advantages of R.F. amplification were realized—even before there were

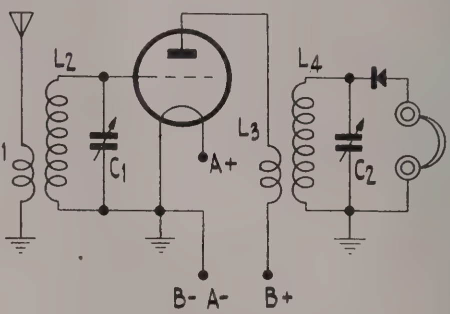


Fig. 45

valves of any sort—so that, after the invention of the triode, these were naturally tried. Immediately, however, a quite difficult problem arose. It was this: that the triode amplified all right, but the amplification was so hard to control that more often than not the circuit proceeded to OSCILLATE. This is a new term for us here, and one which we will have to spend some time explaining at a later date. Briefly, however, it means that the valve, instead of just amplifying the signal from the aerial, produces a signal of its own. Now, we are not at all interested in receiving on our set a strong R.F. signal made by the set itself, for all this can do is to completely mask the very weak signals that our aerial is providing us with. When this happens, we are very lucky indeed if we can hear anything but the signal made by the R.F. amplifier, which has turned itself into an oscillator.

What, then, is the cause of this trouble, and how can it be prevented? In order to look into this one, let us examine a circuit such as we might try to use with a triode valve for amplifying R.F. currents. This is shown in Fig. 45. In this diagram we have the aerial feeding its R.F. currents to earth through an aerial coil, just as we have seen before in crystal sets and one-valve sets. Coupled to the aerial winding is a tuned circuit. This is also an old friend by now, and we can imagine the tuning condenser to be adjusted so that the circuit is tuned to the frequency of the station we want. The lower side of the tuned circuit is connected to earth and to the filament of the amplifier valve. The top end is connected to the grid of the valve, so that the R.F. voltage across the tuned circuit is applied to the grid and varies its volt-

age in the usual way. Next comes the valve itself, and the knowledge we already have of valves tells us that the plate current will vary according to the grid voltage variations, which are the ones caused by the signal. In series with the plate of the valve, we have the small winding of another coil. This has two windings, and we can imagine that it is exactly the same as the aerial coil and tuned circuit. Thus, if we removed the valve and connected the aerial and earth leads, with the primary (small) winding of the second coil, we would have a simple crystal detector circuit, identical with one we have already built.

Because the valve is there, though, the plate current variations are very much greater than the variations of the R.F. current through the aerial winding. In other words, the valve has amplified these currents. So far, so good. Next, we have the second tuned circuit, L_4 C_2. This acts in exactly the same way as the first one, and is tuned with C_2 so that it also is set to the frequency of the signal we want to hear. But because the valve currents through L_3 are much larger than those through L_1, the R.F. voltage of the signal is much greater across L_4 than it is across L_2. This R.F. voltage is now detected by the crystal detector, and the signal is heard in the headphones.

This is the principle upon which a circuit like this can be expected to work. There is nothing wrong with our reasoning, and, as we said above, the circuit really does amplify. Why, then, does it start to oscillate and make a signal of its own? The reason is that

(Continued on page 48.)

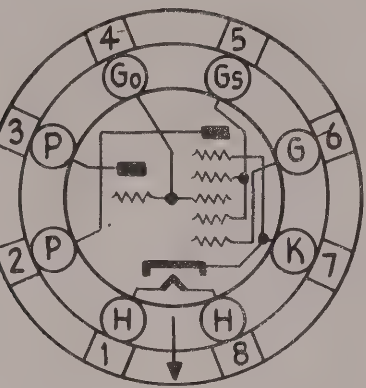
TUBE DATA:

THE 7S7 TRIODE-HEXODE OSCILLATOR-MIXER TUBE

APPLICATION

Type 7S7 is a triode heptode tube designed for converter service. The triode section serves as the oscillator and is internally coupled to the heptode which serves as the mixer. This construction provides minimum frequency drift compared to other conversion methods. Type 7S7 is similar to Type 7J7 except for improved triode characteristics and higher conversion conductance.

Adequate shielding, ruggedness, etc., are provided by the Lock-In construction.



Base connections and electrode arrangement of the 7S7

PHYSICAL SPECIFICATIONS

Base	Lock-In 8 Pin
Bulb	T-9
Maximum overall length	2 25/32″
Maximum seated height	2¼″
Mounting position	Any

RATINGS

Heater voltage A.C. or D.C. (Nom.)	7.0	volts
Heater current (nominal)	0.320	amp.
Max. heptode plate voltage	300	volts
Max. heptode screen voltage	100	volts
Max. heptode screen supply	300	volts
Max. heptode control grid voltage	0	volt
Max. heptode plate dissipation	0.6	watt
Max. heptode screen dissipation	0.4	watt
Max. triode plate voltage	175	volts
Max. triode plate supply voltage	300	volts
Max. triode plate dissipation	1.0	watt
Max. total cathode current	14	ma.
Max. heater-cathode voltage	90	volts

Direct Interelectrode Capacitances:*

Heptode grid G to plate	0.03 $\mu\mu$f. max.
Heptode grid G to triode plate	0.10 $\mu\mu$f. max.
Heptode grid G to grid go	0.35 $\mu\mu$f. max.
Triode grid go to triode plate	1.0 $\mu\mu$f.
Input (signal)	5,0 $\mu\mu$f.
Output (mixer)	8.0 $\mu\mu$f.
Input (oscillator)	7.0 $\mu\mu$f.
Output (oscillator)	3.5 $\mu\mu$f.

*With 1 5/16 in. diameter shield (RMA Std. M8-308) connected to cathode.

TYPICAL OPERATION

Heater voltage	6.3	6.3 volts
Heater current	0.300	0.300 amp.
Heptode plate voltage	100	250 volts
Heptode screen voltage	100	100 volts
Osc. plate voltage (triode)	100	250 volts†
Heptode control grid voltage	—2	—2 volts
Self-bias resistor	240	195 ohms
Oscillator grid resistor	50000	50000 ohms
Heptode plate current	1.9	1.8 ma.
Heptode screen current	3.0	3.0 ma.
Osc. plate current (triode)	3.0	5.0 ma.
Osc. grid current (triode)	0.3	0.4 ma.
Heptode plate resistance	0.5	1.25 megohms
Conversion conductance	500	525 μmhos
Conversion conductance (heptode grid —21 volts)	2	2 μmhos
Total cathode current	8.2	10.2 ma.

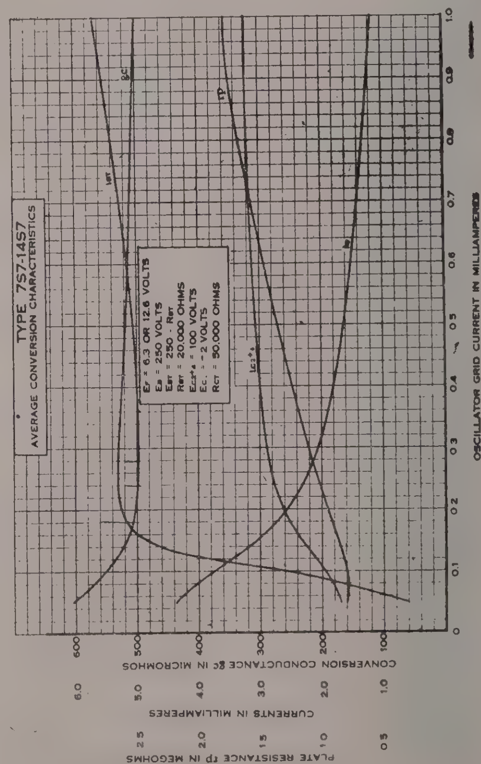
†Applied through a 20,000-ohm dropping resistor properly bypassed.

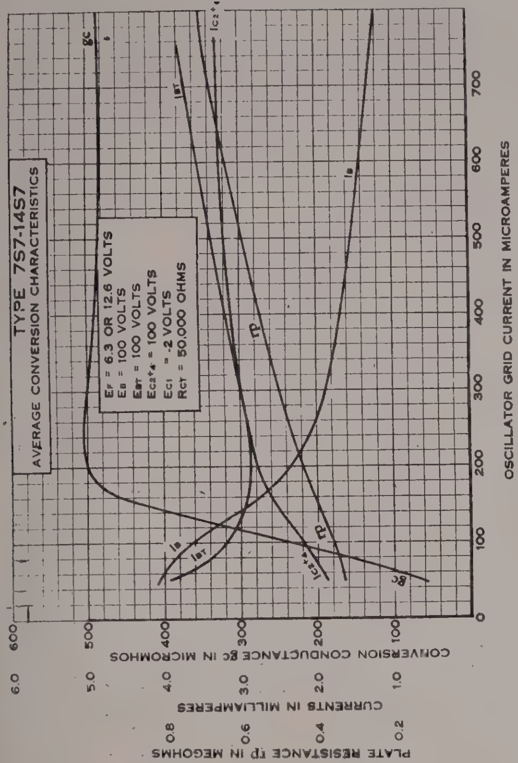
TRIODE CHARACTERISTICS

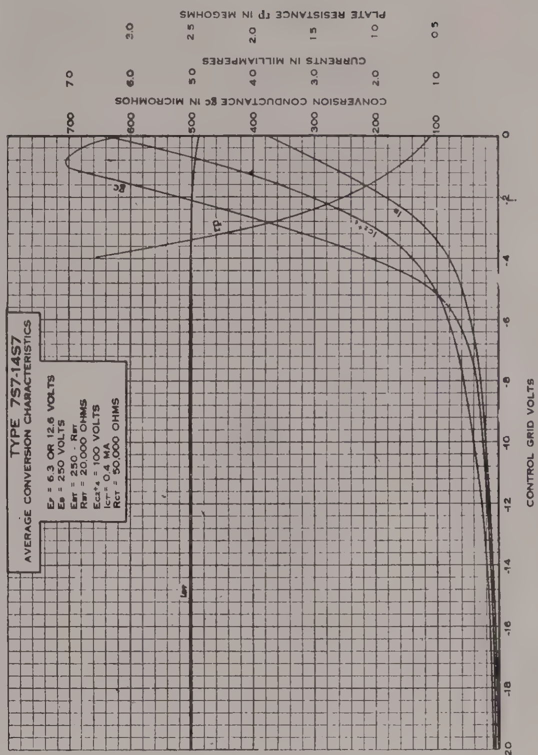
Heater voltage	6.3	volts
Plate voltage	100	volts
Grid voltage	0	volts
Plate current	6.5	ma.
Plate resistance	11000	ohms
Mutual conductance	1650	μmhos
Amplification factor	18	

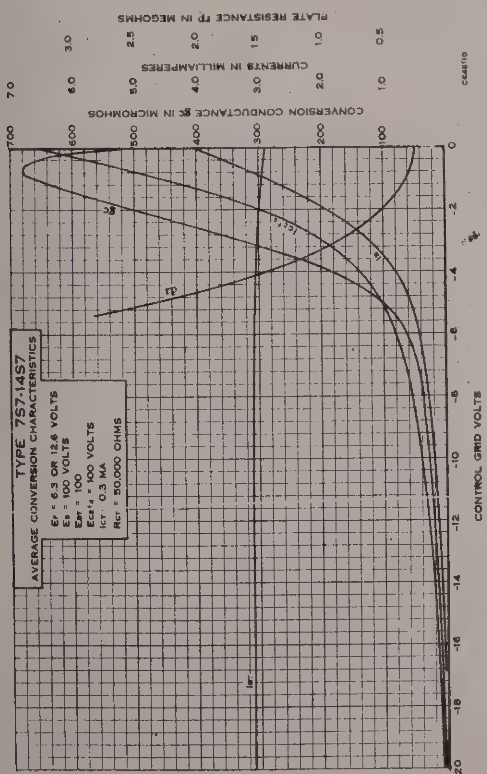
OPERATING CURVES

Below and on the next page are curves for operation at 250 and 100 volts, as given in the above tables.




TYPE 7S7-14S7
AVERAGE CONVERSION CHARACTERISTICS
Ef = 6.3 OR 12.6 VOLTS
Eb = 100 VOLTS
Ebt = 100 VOLTS
Ec2+4 = 100 VOLTS
Ec1 = -2 VOLTS
Rct = 50,000 OHMS
OSCILLATOR GRID CURRENT IN MICROAMPERES
CONVERSION CONDUCTANCE gc IN MICROMHOS
CURRENTS IN MILLIAMPERES
PLATE RESISTANCE rp IN MEGOHMS


TYPE 7S7-14S7
AVERAGE CONVERSION CHARACTERISTICS
Ef = 6.3 OR 12.6 VOLTS
Eb = 250 VOLTS
Ebt = 250 - Rbt
Rbt = 20,000 OHMS
Ec2+4 = 100 VOLTS
Ict = 0.4 MA
Rct = 50,000 OHMS
PLATE RESISTANCE rp IN MEGOHMS
CURRENTS IN MILLIAMPERES
CONVERSION CONDUCTANCE gc IN MICROMHOS
CONTROL GRID VOLTS


TYPE 7S7-14S7
AVERAGE CONVERSION CHARACTERISTICS
Ef = 6.3 OR 12.6 VOLTS
Eb = 100 VOLTS
Ebt = 100
Ec2+4 = 100 VOLTS
Ict = 0.3 MA
Rct = 50,000 OHMS
PLATE RESISTANCE rp IN MEGOHMS
CURRENTS IN MILLIAMPERES
CONVERSION CONDUCTANCE gc IN MICROMHOS
CONTROL GRID VOLTS

ELECTRONIC SWITCH

(Continued from page 18.)

up to the full 100v., and when the positive half-cycles come along practically no diode current flows at all. The result is as seen in Fig. 3 (e) and (f). The diodes do not allow the waveform to go more than a fraction of a volt positive. In America, this circuit is called a clamping circuit rather than a D.C. restorer, and this name emphasizes the fact that the diode "clamps" the waveform at a certain D.C. level. In passing, it may be mentioned that if the diode connections are reversed, the waveform would then go from earth potential to 100v. positive.

PURPOSE OF V_6

The addition of V_6 to the circuit is by way of being a refinement. In any switch such as this, it is unfortunately not possible to have the change-overs from "on" to "off" of the amplifiers occurring absolutely instantaneously. Although the rise and fall of the multivibrator waveforms are very short in duration, they do take some time to occur, and for that reason there are at the moments of switching extremely short periods when both amplifier valves are on together. This does not matter at all so far as the signals are concerned, but this fact is responsible for what are usually called "switching tails," which can appear on the cathode-ray tube. In a well-designed switch these tails are so short in duration that they can hardly be seen on the 'scope, and this is the case with the present design. However, some builders may wish to remove them altogether, unimportant as they are, and V_6 is there for that purpose if desired. If it is not wanted—and it will not be in cases where it is not easy to get at the control grid of the C.R.T., the entire circuit of V_6 can be omitted. For those who wish to include it, however, some description of its action will be necessary. The valve V_6, which is a 6N7, acts as two cathode followers whose cathode load resistor is common. From the screens of the multivibrator valves, very small coupling condensers are connected to the cathode follower grids. These condensers, together with the input impedance of the cathode followers, form differentiating circuits, which allow only the high-frequency components to pass through and severely attenuate the low-frequency parts of the input square wave. The result is that at each change-over period, which is very short and contains virtually all the high-frequency components of the square wave, a negative pulse is applied to the grid of one cathode follower or the other. Because of the fact that the output of a cathode follower is in the same phase as the input voltage, these negative pulses, from whichever pulse they arrive, all appear at the cathode terminal of the 6N7. If now this output is coupled via a blocking condenser to the grid of the cathode-ray tube, the spot is blacked out for the duration of the multivibrator change-over periods, and the "tails" cannot show on the screen.

It should be emphasized that this is a **refinement**, and is in no way necessary to the proper working of the switch unit.

SOME DIFFICULTIES HAD TO BE OVERCOME

Now, to those who are familiar with multivibrators and pulse generation generally, the scheme of this switch will commend itself as a particularly simple one that could be thought up by any one, and such is undoubtedly the case. The principle of operation is quite straightforward, but we would like to emphasize the fact that there are a number of traps for the unwary, and that the design of a really satisfactory switch is not so simple as might appear at first sight. This does not mean that intending constructors need fear that they will encounter grave difficulties in making our circuit work, for the aforesaid traps have been taken care of in the initial design. However, it will be interesting, we hope, and will lead to a better understanding of the requirements to be met by the switch, if some of these preliminary troubles are dealt with here.

The first and most important of these was connected with the waveform actually generated by the multivibrator. It would be an advantage from the cost angle if a dual tube could be used as the multivibrator instead of two separate ones. Since there are no suitable dual pentodes, it might be supposed that it would be quite satisfactory to use a triode multivibrator, in which case a single 6SN7 or similar double triode would serve in place of V_4 and V_5. Such is not the case, however. The reason is that in switching the amplifiers, it is essential that the switching waveform should be as much like those of Fig. 3 as possible. First, the flat tops and bottoms must be really flat, without the slightest bit of curvature. Secondly, the change-over periods must be as short as possible, to prevent the formation of switching tails that compeltely spoil the picture. Neither of these desirable characteristics are even approached by a triode multivibrator. A triode circuit can be used successfully only if followed by a stage of squaring, or in other words an over-driven amplifier, for each output. For best results the squaring valves should be pentodes, so that we should find ourselves with three valves in the switching circuit instead of only two. By far the most elegant solution is the one used here, where the plate circuits of the pentode multivibrator valves themselves act as a stage of squaring, and produce as good a square wave as could possibly be desired. The second point that may not be at all obvious is the complete separation of the amplifiers except for their plates, with the common plate load resistor. If any attempt is made to simplify matters by using a common cathode resistor or common screen resistor, there is again trouble from switching transients, even if the switching waveform is perfect.

Another thing which must not be overlooked is the low-frequency response of the amplifiers, and, for the same reason, that of any Y-amplifier in the 'scope which follows the switching unit. This is not at all an obvious one, and if not realised, may be the cause of much puzzlement. First of all, we must consider what happens in the plate circuit of V_1 and V_2. Now, let us examine for a moment what happens when there are no input voltages applied to either of these valves. They are still being switched on and off by the multivibrator. Considering V_1 and V_2 separately for a moment, it is seen that the application of a square wave to the suppressor must result in the production of a square wave of voltage at the plate of each valve. Now because these square waves are in opposite phase, they will tend to cancel out in the combined output of V_1 and V_2. However, unless it so happens that the circuit is quite sym-

metrical, the cancellation will not be exact, and there will be left at the plate terminal a square wave whose amplitude equals the difference between the individual square wave amplitudes produced by the valves separately. It is possible to make all values in the amplifier circuit nominally the same, and to use valves of nominally identical characteristics, and this is done in practice, but still, there would be slight differences in the amplification of each half of the circuit, so that some residual square wave would be present at the output terminal. What effect would this have on the picture as seen on the 'scope? Simply that the spot would be switched upwards on one half cycle, and downwards on the other. And since each half cycle is long enough in time to allow several time-base sweeps to take place, the only visible effect would be to produce two time-bases on the screen, one above the other. Now, if an input voltage is applied to one of the inputs, the waveform would be seen on one trace, the other remaining blank. If two different inputs were applied, one to each amplifier, then both waveforms would be seen, each occupying the position originally taken up by one of the time-base traces.

In short, a residual square wave in the output of the amplifiers would cause the two traces to separate. This fact is made use of in the actual instrument by putting in the differential screen voltage control R_5. This enables the traces to be superimposed, if desired, because there must be some adjustment of it at which the square wave outputs of V_1 and V_2 actually do cancel. Then, if the control is moved, causing an intentional unbalance, the two traces separate, and their pictures with them, of course, and this can be made to occur in either direction, so that whichever of the two waves we please can be put above the other. As mentioned earlier, if only one input wave is being examined, and if previously the traces have been made to coincide, by manipulating R_5 the unused trace draws the datum line for the waveform that is being examined. This is very useful in estimating whether there are any even order harmonics present, since if there are any, the positive and negative half cycles will be of equal amplitude.

Now, if it should so happen that the amplifiers, either those in the switch unit, or any that this might feed into, cannot handle a square-wave at the 25 c/sec. switching frequency without distortion, the result, in the words of the limerick, would be horrid. The reason is to be found in the type of distortion that occurs when a low-frequency square wave is passed through an amplifier with insufficient low frequency response. What occurs is that the tops of the wave (and the bottoms too) are no longer flat, but become curved, the shape being that of the exponential decay of voltage when a condenser is discharged. Thus, if we look at the C.R.T. screen when no signals are applied to the switching amplifier, instead of a nice fine trace like the usual one, we see a trace that may even be a quarter of an inch wide, owing to the droop in the portion of the square wave that should be flat. The amplifiers in the switch unit are quite satisfactory in this respect, so that if this occurs when it is finally constructed and working, then it is due solely to the fact that the low-frequency performance of the 'scope Y-amplifier is not good enough. The only cure, without re-designing the amplifier is to bypass

it, and feed the output of the switch directly to the plate of the C.R.T.

CONSTRUCTION AND ADJUSTMENT

Very little need be said about the construction of the switch. If it were at all critical as to lay-out, we would have followed our usual practice in such cases and printed a suitable chassis lay-out.

The only precautions that need to be taken are the usual ones that are standard practice with regard to audio amplifiers. Except for the output connection, the whole thing is symmetrical and lends itself very well to a symmetrical lay-out. It should be remembered, though, that some of the condensers are larger than usual, and that a little more space between sockets will be a help in preventing overcrowding. The condensers referred to are C_1 to C_4 inclusive. Since the output of the unit is at a high impedance, it is necessary to keep the output lead short. A good plan would be a cathode follower output stage, which would enable hum-pick-up to be minimized when a following amplifier is used. Where the switch feeds the Y-plate of the C.R.T. directly, this precaution will be unnecessary, as the output level will be so much higher.

In adjusting the unit, once built, we will be in the very fortunate position that a 'scope is available in order to examine the waveforms. We are assuming that no one who has no 'scope will be building it—which seems reasonable!

As explained before, the switching frequency given by the values in the multivibrator circuit is approximately 25 c/sec. If the 'scope time-base is adjusted to this frequency, or better still to 12.5 c/sec., we will be able to see the multivibrator waveforms throughout. First of all it will be instructive to examine those at the screens of V_4 and V_5, and compare them with

those at the plates of the same valves. Then, transferring to the suppressors of V_1 and V_2, we will find that the wave shape is identical with the plate waveforms of V_4 and V_5. Then, with the Y-plate attached to the output terminal, there will be the residual square wave that we have discussed, and this can be balanced out with the aid of R_5. If a low-frequency time-base is used, as suggested, one can see the sequence of events when input voltages are applied to the amplifiers. If a time-base frequency is used that is considerably higher than the switching frequency, then we will have the effect of simultaneous presentation that is required. The showing of the whole process on a low-frequency time-base is an excellent demonstration of how the thing works, and all the points discussed in the text can be seen on the screen.

There is no necessity for the switching frequency to be made variable, and in the interests of simplicity it has not been done. Also, it should be emphasized that there need be no definite relationship between the time-base frequency and the switching frequency. The time-base has to be locked to a sub-multiple of the signal frequency if a stationary picture is wanted, but this has to be done in any case, and locking by means of the synch. control is done in the usual way.

In our next issue we will give reproductions of some of the 'scope pictures that can be seen with the aid of the electronic switch, with various signal and time-base frequencies, and different settings of the trace separation control. These will possibly be of assistance to those who are not used to dealing with peculiar waveforms.

Finally, it may be said to any amateur transmitters who are thinking of indulging in some pulse modulation gear, that in this sort of work, not only is the 'scope a necessity, but so, too, is an electronic switch, and this one should prove very helpful to anyone who is attempting to break into this comparatively new field of amateur endeavour.

Some Applications of the 8012

(Continued from page 11.)

effective bias resistor of 1000 ohms. This would give a bias of 100 volts when the tubes were loaded to 100 ma. plate current, and would prevent them from damaging themselves should the excitation fail. Since this would be enough bias for proper operation, the grid leak resistor would then be omitted altogether.

For grid leak biasing, the value of the resistors would be 50 or 100 ohms.

ADJUSTING AND TUNING UP

Since we are describing the amplifier first, we will assume that a suitable source of driving power is available. Should it not be, the oscillator circuit of Fig. 3 will be found admirable for driving the amplifier with H.T. voltages on it up to 400 volts. For higher plate voltages and the higher power inputs, more driving power than this little oscillator can supply will be needed, but it is desirable to get the amplifier going on reduced power for a start in any case. For an output of from 12 to 16 watts, the 6J6 oscillator will give plenty of drive, and a D.C. grid current of up to 6 ma. for the two 8012's. With this amount of drive, and 350 to 500 volts on the plates of the amplifier, the unloaded plate current should be in the region of 20 to 25 ma. This could probably be reduced, with some slight increase in efficiency, by using a larger grid leak for the 8012's, but under the conditions quoted, the amplifier can be loaded up to approximately 75 ma., and will give more than enough power output to fully light a 12-watt car lamp.

The process of neutralizing the amplifier is not difficult, as long as it is carried out systematically. The first stage in the neutralizing is really part of the construction, where the greatest care is taken to lay out the parts with as complete symmetry as possible. This is not at all difficult, but it is well worth while to work to sixteenths of an inch in placing the grid current components and the neutralizing condensers so that all corresponding leads on the two sides of the amplifier are equal in length. Once the amplifier has been constructed, there is very little control over this aspect, and it is just as easy to take care of it while the construction is under way. However, we will assume that the circuit is as symmetrical as it can be made—and this is much more so than when ordinary tubes are used.

The first step, of course, is to apply excitation, with plate voltage removed, and tune the grid circuit to resonance. In doing this, the two grid-tuning condensers should be adjusted so that resonance is found with approximately equal settings. Next, the neutralizing condensers are adjusted so that the spacing is about one-thirty-second of an inch. This should bring the amplifier into a state of over-neutralization, and if the movable shorting bar is slid up and down the lines, a strong change in grid current will be seen when the plate lines are tuned through resonance, just as if an ordinary tank circuit were being tuned with its condenser.

In adjusting the original model, it was found that the best way of finding an initial setting of the neutralizing condensers was to apply a low plate voltage, with the excitation removed, and to note the grid current that occurs due to the resulting oscillation. It is sufficient simply to flick the plate voltage on and off, and note quickly the grid current, which may be as high as 50 ma. if the circuit is well out of neutralization. Then, both neutralizing condensers are adjusted simultaneously, by a very small amount, and the plate voltage flicked on again. If the grid current is less than before, indicating less violent oscillation, the adjustment of the condensers must have been in the right direction. If greater, the adjustment was clearly in the wrong direction. By proceeding in this way, employing very small steps of condenser adjustment, and taking care that the two are at as nearly the same capacity as possible at each adjustment, it will soon be found that a point is reached where the stage does not oscillate at all when plate voltage is applied, still without excitation. The point is, of course, the one where no grid current flows when the plate volts are momentarily turned on. There is no need to worry about the effect on the valves of this method of testing, as long as the testing plate voltage is low, and this can best be seen to by placing a 5 or 10k. resistor in series with the plate supply. Needless to say, when approaching the point where there is no oscillation, the plate voltage should be kept on only long enough for a grid current reading to be taken.

When the no-oscillation adjustment has been found, the stage will be quite near to correct neutralization, and final adjustments can be made by moving **one** neutralizing condenser only; as before, the plate voltage is applied after each change, and by this means it will be possible to find the two positions of the one condenser between which no oscillation occurs. The condenser is then set midway between the two positions mentioned, and the same process is gone through with the other one. When this has been set similarly, the resultant settings of both should be correct for neutralization.

At this point, excitation can be applied again, and with no plate voltage on, the plate circuit can be tuned through resonance with the movable shorting bar. It should now be found that the grid current shift when the plate circuit goes through resonance is quite small.

The next test is to apply both excitation and plate voltage, the latter preferably still reduced. The movable shorting bar is now "hot," and should not be moved with plate voltage applied, but if neutralization is correct, and slight adjustments are made to the bar, and the H.T. turned on after each adjustment, it should be possible to find a very sharp minimum plate current. A sure sign of improper neutralization is when tuning the plate line causes, not just a sharp drop in plate current at resonance, but indeterminate jumps, accompanied by sharp jumps in the grid current.

It should be possible to make the amplifier quite stable without loading it up at all, but it will often be found that coupling a load, such as an aerial or dummy load, to the plate lines will render stable operation possible. If this is found, it simply means that neutralization is nearly correct, but not quite, and it may be quite possible to operate the stage in this condition. The operation can be termed satisfactory if with excitation and load applied, the grid current stays the same, or drops slightly when the plate voltage is turned on. If there is an increase of grid current, it probably means that the amplifier is regenerative, even if it is not oscillating. The acid test of whether neutralization is well enough done or not is to apply modulation and examine the trape-

zoidal modulation pattern on a 'scope. This will soon indicate if regeneration is present, as the sloping sides of the trapezium or triangle will be curved in a concave manner, indicating that the output voltage rises at a faster rate than the plate voltage does during the upward swing of the modulation cycle.

We have spent a great deal of time and space describing the adjustment of the amplifier, but this is not to say that it is in any way a difficult process. Certainly, it needs to be done with more care than in low-frequency stages, but this is really only because slight adjustments to any of the circuit capacities makes a larger percentage difference to the performance, the higher the frequency. Once correct neutralization had been effected, the prototype was found to behave as tractably as any R.F. power amplifier we have had anything to do with.

A SINGLE 8012 AS A V.H.F. OSCILLATOR

The 8012, as might be expected, makes an excellent oscillator, either singly or in push-pull, and it can be expected to make a very good frequency multiplier as well, though we ourselves have done no work along this line as yet. However, there seems no good reason why, if sufficient excitation is available, a pair of 8012's should not work extremely well as a push-pull tripler. This should enable the 420 mc/sec. band to be reached by tripling from the higher end of the 144 mc/sec. band.

As an oscillator, however, there should be no difficulty in building a self-excited rig for the 144 or 420 mc/sec. bands. Since the data is already available for the 'former, we will say little more about this band at the moment. An obvious method of putting out a strong signal on 144 mc/sec., as long as one is not worried about crystal control, is to build the amplifier circuit exactly as specified, and to omit the neutralizing condensers, thus turning it into a first-class tuned-plate tuned-grid push-pull oscillator. Nor would there be any difficulty at all in using a single 8012 as a Colpitts or ultra-audion oscillator, with an ordinary lumped L/C circuit as the tuning element.

A SINGLE-TUBE OSCILLATOR FOR 420 mc/sec.

For the higher frequencies, the oscillator circuit shown in Fig. 4 is a very good one. It will always oscillate, and is very simple to construct. From the

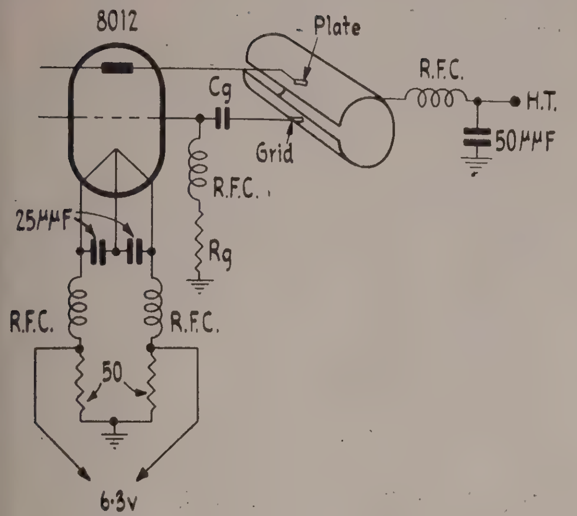


Fig. 4.—The 420 mc/sec. oscillator.

circuit point of view, it can be regarded as a Colpitts oscillator, the tuned circuit for which consists of a single-turn coil of unconventional shape. As can be seen from the diagram, the "coil" consists of a hollow cylinder, with a gap along its length. It can be regarded as a single-turn coil, made of "wire" of rectangular cross-section. The gap in the cylinder gives the whole thing a certain amount of capacity, and there are also the valve capacities connected across it. Thus, the whole forms a tuned L/C circuit. The idea of it is this, that the cylinder can be regarded as a single-turn coil made up of a large number of single-turn coils, of square cross section, connected in parallel. Now, it is well known that when inductances are connected in parallel, the resulting inductance is less than that of the individual inductances, and, indeed, less than that of the smallest, if they are not equal, just as the same considerations apply to resistances in parallel. Now, comparing the cylinder circuit with a single-turn coil of the same diameter, but of square cross-section equal to the thickness of the cylinder wall, it is obvious that the latter must have considerably less capacity across the gap than the cylinder itself. Thus, it might seem that increasing the length of the cylinder would not necessarily raise the frequency to which it tunes. It does, however, because, as the cylinder is made longer, the capacity increase is slower than the decrease in inductance, so that, all told, keeping the diameter of the "turn" constant, and increasing its length results in raising the frequency to which the circuit tunes. This kind of tuned circuit has the additional advantage of very high Q, which makes it invaluable at very high frequencies, and oscillators have been built with this type of tuned circuit that work up to over 1000 mc/sec. Now, the cylinder is essentially a balanced affair, the high potential

points being found at the gap. There must therefore be a point of zero R.F. potential at any point along a line diametrically opposite to the gap. Thus, to make our Colpitts oscillator, all we have to do is to connect the plate to one edge of the gap, and the grid to the other edge, through the usual blocking condenser, and to connect the H.T. to the circuit at any point along the length of the cylinder, directly opposite the gap. The filament circuit must be "up in the air" to R.F., and so the circuit used is as in Fig. 4. The three filament wires are still connected in parallel by 25 $\mu\mu$f. condensers, but the centre one is no longer earthed. Instead, R.F. chokes are inserted in each lead, and the 100-ohm centre-tapped resistor connected across the "cold" ends of the chokes.

For 420 mc/sec., the chokes can be made of 20-gauge wire, and can be wound with 10 turns on a diameter of $\frac{1}{4}$ in. At this, they will be self-supporting.

The dimensions of the cylinder can vary within quite wide limits, so we have prepared a table showing the frequency obtained with cylinders of particular dimensions. The cylinders should be mounted at right-angles to the direction of the plate and grid connecting wires of the valve, and the connections should be made as short as possible. As can be seen from the diagram, the connections are not made right at the edges of the gap, but about a third of the way round the cylinder towards the back. This has the same effect as tapping down on an ordinary tuned circuit. The cylinder can be supported by means of a horizontal stand-off insulator, mounted on a bracket, the mounting point being at the centre of the line opposite the gap in order to preserve symmetry.

TUNING THE OSCILLATOR

The one drawback of cylinder circuits is that without some careful mechanical work, in order to insert a similar cylinder inside the first one, allowing very small spacing, and rotating the inner one for tuning, it is not easy to tune a cylinder over a band of frequencies. However, for experimental work, this should not matter very much, and, in fact, will in some ways be an advantage, as the frequency stability is quite good. However, an easy method of tuning is to vary the grid condenser, C_g. This can be varied over a range of 5 to 15 $\mu\mu$f. without spoiling the oscillation characteristics, and a change of 5 $\mu\mu$f can be made to vary the tuning from 420 to 450 mc/sec. The grid R.F. choke should be the same as the cathode ones. Since the oscillator is likely to be used with a wide variety of plate voltages, we have not specified the size of grid leak needed, but somewhere between 5 and 10k. will be found satisfactory. Higher values will give reduced plated current compared with lower ones, and can be recommended for experiments, to save the tubes.

(Continued on page 48.)

RAINBOW COMMUNICATIONS RECEIVER

(Continued from page 6.)

the 455 kc/sec. input from the tuner, and to give a 100 kc/sec. I.F. output. Thus, T_3, in the plate circuit of V_1 is the first 100 kc/sec. I.F. transformer. The I.F. amplifier, V_2, is slightly unusual in that it has a single diode, as mentioned above, which is used as the A.V.C. rectifier. The purpose of this arrangement is two-fold. First of all it frees one of the diodes of V_3, enabling it to be used as a noise-limiter. Secondly, it enables very short leads to be run from the I.F. amplifier to the A.V.C. diode. It will be seen that the latter is fed directly from the plate of the I.F. amplifier, which gives a larger D.C. output than when the secondary of the last I.F. transformer. This makes for a larger degree of A.V.C. control, and therefore more effective control. The coupling condenser C_{10}, is wired in right at the valve pins. This is a very good thing from the point of view of stability of the I.F. amplifier, because at the plate of this valve is to be found the highest radio frequency voltage in the set, and a long lead from here to the A.V.C. rectifier makes it possible for the plate circuit to radiate quite strongly, and is sometimes the unsuspected cause of oscillation in an otherwise stable set. The EAF41 has its screen supplied from a dropping resistor so as to realize the full benefit of the remote cut-off, and to give the best handling capacity for strong local signals. R_9 is the A.V.C. rectifier load resistor, and R_8, together with C_9 form the audio frequency filter which removes the unwanted audio components from the output of the A.V.C. tube. The A.V.C. line is connected to the common connection of the switch Sw_2, which is the A.V.C. on/off switch. A blue lead comes from the tuner, and this is the one through which A.V.C. is applied to the valves therein. When the switch is in the "up" position, the grid circuits of all the R.F. valves are therefore connected to the filter resistor R_8(and thus receive A.V.C. control voltage. When Sw_2 is in the "down" position, the same grid circuits are disconnected from the A.V.C. circuit, and are connected to the moving arm of R_{29}. This resistor is a source of variable negative voltage, and is the manual gain control, mounted on the front panel of the set. When A.V.C. is in use, this control is disconnected from the valves, and moving it has no effect, but when the A.V.C. is tuned off, the manual control is automatically brought into operation.

2ND DETECTOR AND NOISE-LIMITER CIRCUIT

The 2nd detector (perhaps it should be called the 3rd, in this set) is the left-hand unit of V_3, while the right-hand one is the noise-limiter diode. The load resistor for the detector section consists of R_{15} and R_{14} in series. Usually, R_{14} would be made approximately one-tenth of the value of R_{15}, and would act solely as part of an R.F. filter, keeping the I.F. voltage out of the audio amplifier. Here, however, for reasons connected with the operation of the noise-limiter, these resistors are equal in value, and an extra resistor, R_{14}, is placed in series as the filter resistor. C_{17} couples the audio output to the grid of the 6J7 first audio tube in the ordinary way. The action of the limiter is as follows: At the top end of the chain of resistors R_{14}, R_{15}, and R_{16}, we have an audio filter R_{13}, C_{15}. At the junction of these two components, there thus appears a negative D.C. voltage, which is applied to two points in the remainder of the circuit. First, it goes to the grid of the magic eye valve, operating this tube in the usual way. Secondly, through Sw_1, the D.C. output of the detector diode is applied to the plate of the noise-limiter diode. The latter therefore has a negative bias on the plate, proportional in size to the strength of the incoming carrier. In the normal course of events, therefore, the limiter diode cannot conduct, and it is effectively an open circuit across the serious combination R_{14}, R_{15}. The cathode of the limiter diode is connected to the junction of R_{15} and R_{16}, and therefore has an audio voltage applied to it, equal to half the maximum amplitude developed by the detector circuit. Now, this audio voltage swings the cathode in a positive direction during alternate half-cycles of the audio signal, but even when the carrier is 100 per cent. modulated, it can never swing far enough positive to allow the limiter diode to conduct. The effect of the diode is therefore exactly nil, as long as there is no noise present as well as the signal. Now noise, of the kind made by "static," or ignition systems, consists of very short impulses which are amplified in the receiver, and finally rectified by the detector. If these impulses are higher in amplitude than corresponds with 100 per cent. modulation of the carrier being received by the set, the cathode of the limiter valve will be driven momentarily more negative than its plate, so that it is able to conduct. When this happens, the effect is that of a short-circuit on the load resistor R_{16}. As a result, the input to the audio amplifier is momentarily and automatically cut off for the duration of the noise pulse, and this is not heard in the output to nearly the same extent as it would otherwise be. The noise limiter cannot **eliminate** noise, but does reduce it quite considerably, and is a worth-while addition to any set used for short-wave listening.

AUDIO AMPLIFIER AND B.F.O.

The audio amplifier and B.F.O. circuits are straightforward, and require very little comment. Negative feedback is supplied to the former, and the coupling condensers are purposely made very small. This is to reduce the low-frequency response, so that on broadcast, the sound will be pleasing in spite of the lack of "top" occasioned by the high I.F. selectivity.

The B.F.O. works on 100 kc/sec., and uses a special coil, which has some fixed capacity built in, and is slug-tuned for adjusting the centre frequency. Tuning is done with C_{28}, which is brought out to the front panel, and is the B.F.O. pitch control. Instead of an on/off switch, one of the rotor plates of C_{28} is bent so that the condenser short-circuits itself when turned to full capacity. This does no harm to the oscillator valve, since the plate voltage is so low that even when not oscillating, it cannot draw excessive plate current.

POWER SUPPLY AND MANUAL GAIN CONTROL

The power supply is slightly complicated by the fact that a back-bias system is used to provide a source of negative voltage for the manual control of gain when the A.V.C. is switched off. The back-bias resistor is R_{31}, and it should be noted that the first filter condenser is returned to the negative end of this resistor, and not directly to ground. This is to reduce the hum voltage across it, and so is the large electrolytic condenser by which it is shunted. R_{30} is inserted to form some control over the H.T. voltage available, and to give a little extra smoothing. It is a 10-watt wire-wound resistor, with an adjustable band, and this can be set so that the voltage on the H.T. line is exactly 250 volts.

CHASSIS AND CONSTRUCTION

The circuits shown on the diagram are not very critical as to layout, but in the original model care was taken to see that the circuit progression was followed as closely as possible in practice. The layout is shown in the photographs. A large cut-out is made to accommodate the tuner, and practically all the rest of the set is arranged in order along the back of the chassis. In the top-chassis photograph, we have the power transformer and smoothing choke on the left, and in front of them can be seen the EF41 B.F.O. valve, and beside it, almost hidden, is the B.F.O. coil. Along the back of the chassis, from left to right, are, the 80, the 6V6, the 6J7, the 6H6G, and the second 100 kc/sec. I.F. transformer. In the corner is the EAF41, and in front of it can be seen the first 100 kc/sec. I.F. transformer. Beside this, to the left in the picture, is the 455 kc/sec. I.F. transformer, and directly in front of this are the ECH41, and the 355 kc/sec. oscillator coil. Then, on the unit chassis, are the first ECH41 and the EF41 R.F. valve.

This arrangement is probably the most logical that could be devised, and is the one followed on the chassis which S.O.S. have had made to sell as part of the complete kit.

Underneath, the same arrangement can be followed quite readily. There is a baffle shield, which can be seen in the top left-hand corner, and which encloses the parts of the second ECH35. This is not needed for stability, but is there to help prevent radiation of harmonics of the 355 kc/sec. oscillator into the R.F. end of the set. From left to right, the controls are as follows: C_7, the extra bandspread control; R_{31}, the manual gain control; Sw_2, the A.V.C. on/off switch; Sw_1, the noise-limiter on/off switch; the tuning knob; the audio gain control; R_{16}, and the B.F.O. pitch control, C_{28}.

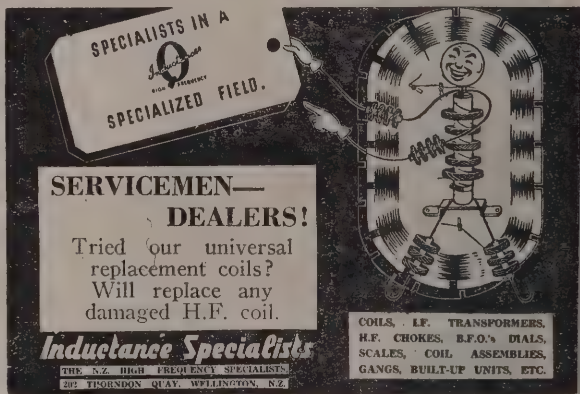
THE EXTRA BANDSPREAD CONTROL

So far, we have not described the action of this control. As can be seen on the circuit, it is a fine tuning control on the second oscillator. It therefore acts as a fine tuning control for the **second** superhet. section of the set, and since the latter is much more selective than the single 455 kc/sec. transformer which feeds signals into it, this control allows very fine tuning of any signal which has been roughly tuned in by means of the ordinary dial. In some cases it will be possible to use this control to tune between two or more very closely spaced stations, which are all within the pass band of the 455 kc/sec. transformer at the same time. One novel feature is that since it tunes the second superhet. portion of the receiver, it will give exactly the same degree of bandspread, whether the main dial is tuned to the broadcast band or to the highest frequency on the short-wave bands. It will be found particularly useful to amateurs in separating signals in a crowded band, and to short-wave fans in getting exactly correct tuning of a short-wave station. The range covered by the control is only about plus and minus 15 kc/sec. about the frequency indicated on the main dial. An engraved escutcheon will be available, stating the functions of all the controls, and included on it will be a calibration of the bandspread control, in terms of kilocycles departure from the centre frequency, which is wherever the main dial happens to be set.

ALIGNMENT

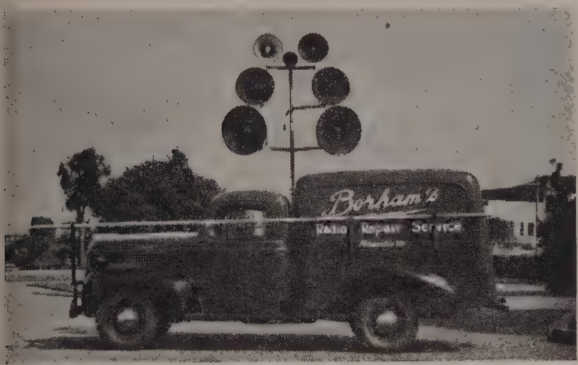
It might be supposed that a double-conversion superhet. like this one is difficult to align, but such is not the case at all. Starting, as usual, from the final detector and working backwards, we have first of all to align the 100 kc/sec I.F. stage. When both 100 kc/sec. transformers have been trimmed for maximum output, we have to set the frequency of the second oscillator to 355 kc/sec. This is done in the following way. First, the extra bandspread condenser, which is merely a trimmer on the 355 oscillator, is set to half capacity. Next, the signal generator is set to 455 kc/sec., and is fed to the grid of the second mixer. This having been done, the tuning slug on top of the 355 oscillator coil is adjusted until the 455 kc/sec. signal is tuned in, and is "right on the nose." All that is left now is to line up the 455 kc/sec. I.F. transformer, and this is done by feeding the signal generator into the grid of the FIRST ECH41, which is the one on the tuner unit, and then trimming the 455 kc/sec. I.F. transformer for maximum response, without touching the frequency setting of the signal generator.

It is clear from this that a signal generator is desirable for aligning the set, so, if one does not possess one, it would be a good idea to have at least the 100 kc/sec. amplifier and the 355 kc/sec. oscillator lined up by someone who has one. The "Rainbow" tuning unit itself should not need aligning, since this is done before delivery, with the valves in place, and the trimmers all sealed. When the prototype set was built in our own laboratory, it was found quite unnecessary to touch the trimmers of the tuning unit, in spite of the fact that it had travelled all the way from Auckland to Wellington.

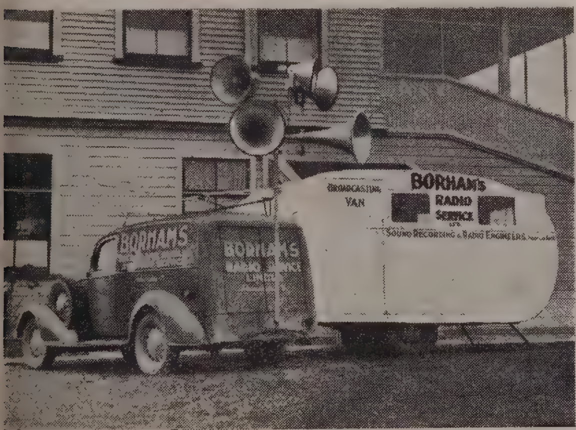


OUR GOSSIP COLUMN

A WELL-KNOWN P.A. SYSTEM



One of the largest and most up-to-date public address systems in the North Island is the one owned and operated by Mr. E. B. Borham, of Palmerston North. Illustrated here are two of Mr. Borham's vehicles, which are equipped with the most modern P.A. gear and are designed so as to make them suitable for a wide variety of jobs. The caravan is specially designed for racecourse work, and contains a number of separate amplifying systems which can be put into operation simultaneously or singly, and which provide for standby equipment in the event of breakdowns.



One of the biggest jobs recently undertaken by this progressive firm was the provision of P.A. facilities at the Manawatu Show. Three systems were needed, with the added facility of being able to link them all into one large system at certain times. Sixteen speakers were needed to cover the oval and the outside enclosure, and a further seven covered the cattle section of the show.

Another interesting feature of the installation was that seven points throughout the grounds had to be linked by means of an intercom. system, which, of course, required its own special equipment.

If anyone thinks that P.A. work comprises little more than feeding an amplifier (or amplifiers) into a number of speakers, the provision of facilities such as these would probably convince him otherwise!

Mr. Borham and his mobile P.A. systems have become well-known figures in and around most of the racecourses in the Manawatu district, from Otaki to Waverley, and he has visited the "Radio and Electronics" office several times while on his not infrequent visits to the capital.

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MARINE SERVICE NAME-PLATES

Mr. A. E. Woods, governing-director of Electronic Navigation, Ltd., when interviewed in Auckland, advised that the recent reorganization of their marine department and name-plate section is working smoothly, and the benefit derived from the change of premises has had a marked increase in efficiency and production. Several changes of staff have been effected, the Marine Service Department now being in charge of Mr. P. Smythe, who was with the New Zealand Shipping Co. for 13 years. In England, Mr. Smythe completed two courses in radar service, and is experienced in the service of depth-recording and communication equipment. At the express wish of his new employers, Mr. Smythe completed a Sperry-gyro course prior to his departure from England.

The control and organization of the company's Wellington branch is in the capable hands of Mr. L. Johnson, late chief radar mechanician on the staff of Dominion Laboratories. Mr. Johnson was most active in marine and ground station radar whilst at the "Lab.," and he is also a capable communications technician, at one time being employed by Standard Telephones and Cables, Ltd., on marine service. His duties in Wellington will bring him into close association with the New Zealand Federation of Shipowners in the maintenance of marine equipment in that port.

As designing engineer to the company, Mr. A. R. Chesterman is now fully occupied in the designing of new equipment and the final testing of the various electronic plants manufactured at Nagel House.

Mr. A. Yates is in charge of the assembly and wiring section, and is also in control of the machine shop.

Although the word "name-plates" has been deleted from the company's letterheads, this side of the business is still going strong, under the capable leadership of Mr. E. S. Warhaft, assisted by his draughtsman, a printer, and an etcher.

* * * *

Mr. A. J. Wyness, managing-director of H.M.V. (N.Z.) Ltd., left by the Corinthic in March for Great Britain, on a general business trip, embracing all sections of his company's activtities in the radio and gramophone record fields.

Mr. W. A. Donner, managing-director of Columbia Graphaphone (Aust.) Pty. Ltd., Sydney, has been visiting New Zealand recently. Mr. Donner will be closely associated by Mr. J. Wyness, of H.M.V. (N.Z.), Ltd., Wellington.

Visiting Wellington recently for the branch managers' conference of the Swan Electric Co. Ltd., were Norm Chiswell, of Dunedin, Ken Schollum, of Christchurch, and Dave Reid, of Auckland.

* * * *

Mr. C. S. Peate, of Scott Bros., Christchurch, and Mr. C. J. Lenihan, of Turnbull and Jones, Wellington, were re-elected chairman and vice-chairman respectively of the New Zealand Electric Range Association at the annual general meeting of the above association held in Wellington. (Continued on page 48.)

TRADE WINDS

RUSSELL IMPORT CO., LTD.—CHANGE OF PREMISES AND STAFF

This company, having expanded so much during the past year, in addition to appointing three field representatives covering the whole of New Zealand, has found it necessary to move into larger offices. The staff will be pleased to welcome old and new friends at their new premises in Selfridge's Building, 55-57 Dixon Street, Wellington, where the company has been fortunate in securing 2000 square feet of office space, which, in addition to showrooms, etc., will enable even better service to be given to the radio, electrical, and musical trades.

Russell Import's team, whose members are well known to the above-mentioned industries, consists of:

Manager: Mr. W. L. (Bill) Young.
Accountant: Mr. J. S. (Joe) Battiston.
Southern North Island Representative: Mr. J. W. (Jack) Ramsden.
Northern North Island Representative: Mr. W. D. (Doug) Billings.
South Island Representative: To be appointed.

* * *

N.Z. RADIO TRADERS' FEDERATION

The president (Mr. G. J. Markby), whilst in Wellington recently, arranged, after discussion with headquarters, for the annual meeting to be held on 23rd March. A report of this meeting will be found elsewhere on this page.

* * *

Swan Electric Co., Ltd., advises that it has been appointed New Zealand distributors of Cossor valves. At present there are in stock the main types of the 6.3v. loktal series, which are direct equivalents, type for type, of the similarly numbered American loktals. The 1.4v. miniature battery series is also available.

* * *

NEECO STAFF APPOINTMENTS

The National Electrical and Engineering Co., Ltd., has announced the appointment of Mr. P. D. England to the position of sales manager at its Head Office, Wellington.

Phil England joined the company in March, 1941, and his first assignment was as traveller for the Auckland branch. Previously he had been employed with the local organization of Siemens, handling the products of its German factories.

When in 1922 a municipal electric supply undertaking was commissioned in Wanganui, the company opened a branch office in that city, with Mr. England in charge. Under his management the branch rapidly became an important element in the company's sales outlets.

In 1935 he obtained long leave, and on his own initiative paid a visit to the United States of America, during which time he called at several of the G.E. factories to get first-hand knowledge of the technique of manufacture of products handled by him at Wanganui.

Mr. England's sales territory has been in the Taranaki province as far as Waitara to the north, and the north-western portion of Wellington province, and his genial personality is well known, not only in electrical trade circles, but amongst the motoring fraternity also, as for a number of years he has been the popular president of the Wanganui Automobile Association. In spite of these preoccupations, Mr. England has found time to devote to golf, and the garden at his home on St. John's Hill is a veritable delight.

Jack Simpson, of the Wellington branch, succeeds to the management at Wanganui. Jack has many years' service to his credit with NEECO, and is not unknown to the Taranaki district, where he is sure of a cordial welcome.

* * * *

NEW ZEALAND-MADE RECORDINGS

With presses which can make a record every 40 seconds, and production based on 200,000 records annually, H.M.V. (N.Z.), Ltd., expect to cure the dearth of popular and modern types of recordings. A member of the "Radio and Electronics" staff was privileged recently to listen to some of the initial records just off the press, the results of which give promise of popular favour. The new factory at Kilbirnie is expected to commence operations for commercial production by the beginning of April. Mr. J. Wyness, of H.M.V. (N.Z.), Ltd., told "Radio and Electronics" that present import licences were sufficient to supply only 20 per cent. of the demand, so that with his company producing the popular types of recordings, such licences can be used to cater more for the discriminating user of the classical and educational type of record.

* * * *

"Inductance Specialists Universal Inductance Coils: Adjustment Procedure."

Inductance Specialists, Wellington, have issued a special technical pamphlet on the correct procedure for the installation and adjustment of their Universal replacement coils for broadcasting receivers. This is available free on request from the abovementioned firm.

ANNUAL CONFERENCE OF THE N.Z. RADIO TRADERS' FEDERATION

Delegates to the New Zealand Radio Traders' Federation met in Wellington for the annual conference on 24th March. Among those present were—

Mr. G. J. Markby (president), Christchurch,
Mr. S. D. Mandeno, Auckland,
Mr. E. B. Borham, Palmerston North,
Mr. W. I. Cunninghame, Wellington,
Mr. K. W. Walker, Nelson,
Mr. I. R. Cosgrove, Wellington,
Mr. B. McLean, Wanganui,
Mr. D. J. Reid, Auckland,
Mr. D. B. Billing, Wellington,
Mr. J. Fairclough, Napier and district,
Mr. C. G. Camp (secretary),
Mr. D. R. Cattel (assistant secretary).

In welcoming the delegates, Mr. G. J. Markby said that, with such a good representation from most centres, he felt the deliberations would prove well worth the travelling time in coming to Wellington.

The annual report covered a wide range of activities, showing a growth in membership and greater enthusiasm among wholesale and retail members working for the interests of the industry as a whole. Since September, 1948, radio licences had increased by 14,000, there now being a total of more than 428,000 radio listeners licensed in New Zealand.

STATEMENT SHOWING THE NUMBER OF RADIO LICENCES IN FORCE AS AT 30/9/48

District	Receiving Licences.					Private Experimental.	
	Receivers	Dealers	Multiple	Special	Free	Amateur	Research
Auckland	146,718	610	15	1	692	550	4
Canterbury	75,440	298	26	1	329	276	—
Otago	56,684	225	16	—	235	206	3
Wellington	149,675	616	26	1	631	683	4
Totals	428,517	1749	83	3	1887	1715	11
	Grand total, 433,965						
Totals as at 30/9/47	414,418	1549	60	2	1801	1444	8
	Grand total as at 30th September, 1947, 419,282						

The report dealt with the National Broadcasting Service and its proposed activities for increase in transmitter service, new buildings, etc., for greater and more complete coverage. With regard to F.M., the annual report of the Director of Broadcasting intimated that expenditure of money on this new system was not justified under present conditions in New Zealand, the existing A.M. system still permitting many channels to be available for new stations.

Frequency alterations brought about by the New Zealand Broadcasting Service on 2nd June last had brought forth severe criticism from the trade, and in many instances retailers had incurred considerable financial loss through the authorities not having taken the trade into their confidence. Since the change, keen disappointment has been expressed from a number of quarters, especially from South Auckland, Gisborne, Canterbury, and Otago areas, with the results achieved from the alteration in operating frequencies.

Once again the Federation has taken up the matter of representation on the Board of Electrical Wiremen's Registration, but unfortunately without success.

The meeting resolved itself around many important trade matters generally, including industrial economics and Price Tribunal matters. Remits from branches, including publicity and membership, absorbed much discussion, resolutions being passed for action by the respective associations and finalization by the Federation.

A discussion took place upon the matter of special broadcast notices, it being resolved to request the Broadcasting Service to set aside a time of the day for the broadcasting of special notices, such as those for missing persons, etc., so that listeners could become familiar with a definite hour for this feature.

Officers elected for the ensuing year were: President, Mr. G. J. Markby (Christchurch), re-elected; Vice-presidents, Mr. J. Fairclough (Napier), Mr. E. B. Borham (Palmerston North, delegate for North Island Minor Association), Mr. K. W. Walker (Nelson, delegate for South Island Minor Association); Auditors, Messrs. G. Y. Berry and Miller. Other delegates to be elected from the four major associations.

The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of New Zealand.

No. 18: A FOUR-BAND EXCITER UNIT FOR 80 TO 10 METRES INCLUSIVE

The last two issues of the Experimenter described the circuit and mechanical construction of a variable frequency oscillator, speciall designed as a transmitting frequency control. The so-called Clapp oscillator circuit was used, with a fundamental oscillation frequency of 1.75 to 2.0 mc/sec., followed by a doubler stage, which gave a measured output of 400 mw. on the 80m. band. Since this unit can be regarded as the first stage of an amateur transmitter for all the H.F. bands, we are following up here with an exciter unit which will give output on any amateur band from 80 metres to 10 metres inclusive. This forms the next stage of the transmitter, and when its description is complete, we will go on to describe suitable 100-watt final stages, thereby completing the transmitter.

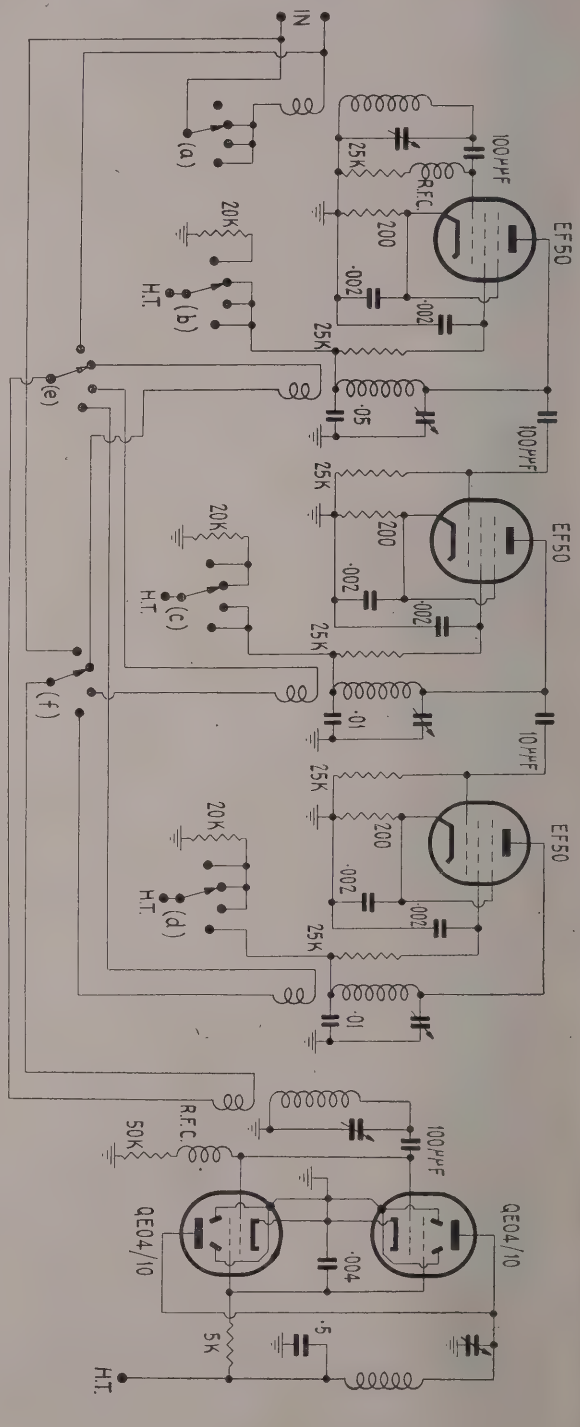
SCHEME OF THE EXCITER

The subject of exciter units is one fraught with possibilities. So many are they that some builders have the greatest difficulty in making up their minds which of the many recommended arrangements is the one best suited to their needs. However, we have tackled the problem from scratch and have used the following principles and arguments in arriving at the final set-up.

First, it was decided that the frequency multipliers should operate at as low a power level as convenient. This decision leads to real economy, as the three multipliers are not only at receiving tube level, but small receiving tubes are used at that. Many exciters aim at providing enough power from each multiplier to drive the final amplifier, which is supposed to be the sole generator of much R.F. power, but since the designers have often previously been bitten by the bugs which always attend an under-excited final, they see to it that plenty of power will be available on the highest frequency by the simple process of using larger valves and lower efficiencies throughout the exciter than are really necessary. This runs away with a deal of D.C. input power to the multipliers, and results in the earlier stages at least having a large excess of power output, which is merely wasted.

The need for a substantial reserve of driving power for any final amplifier is not questioned. What we do maintain, however, is that comparatively high-powered frequency multiplier stages represent a very wasteful way of getting it. What we have done instead is to use low-powered multipliers, and to finish the exciter proper with a stage of straight amplification, capable of providing ample power output for all contingencies and yet calling for only a very small driving power itself. The valve which enables us to do this is the small transmitting beam tetrode, the QE04/10, or, as it is sometimes numbered, the QV04/7. Valves with these type numbers are identical, physically and electrically.

A glance at the circuit diagram on this page shows that three EF50's have been used as the multipliers, and these are shown as driving a pair of



QE04/10's in parallel. It should be pointed out at the outset that the full power output of which the amplifier stage is capable will not always be needed. As drawn, this stage can deliver a good 15 to 16 watts of R.F. output on any band. This will be found sufficient for driving any triode final amplifier with 100 watts D.C. input to its plate, but will clearly be much more than enough if the final stage is to use one or more pentodes, with their very small driving power requirements. In this case, two courses are open to the builder. First, he can construct the multipliers and find out by trial whether the output power is sufficient to drive his projected final. Alternatively, if the multipliers will not do the trick on their own, he can incorporate the QE04/10 amplifier, **but with one valve omitted.**

BAND-SWITCHING USED

A feature of the present design that will please many is that, in the multiplier chain, band-switching has been used. Six switch levels are needed, and these can easily be provided by an ordinary wafer-type of wave-change switch, having four positions, and three double wafers. Since all the R.F. switching is done at low power level, and also at low impedance, it is quite unnecessary for the switch to be of the expensive ceramic type. By the same token, there is no need to use high-quality polystyrene formers for the coils. Ordinary bakelized paper tubing was found quite satisfactory for the multiplier coils, and saves considerable expense.

The system of switching is as follows: The terminals marked "in" receive the twisted pair output leads from the V.F.O. At this point there appear two branches. One goes to the first coupling coil, which is either open-circuited or fully connected by wafer (a) of the wave-change switch. The second branch goes to wafers (e) and (f) of the wave-change switch. An examination of the connections thus made will show that when the switch is in the left-hand position (Position 1), the V.F.O. output is connected stragiht through to the grid-coupling link of the QE04/10 amplifier. At the same time, the coupling link to the first EF50 is disconnected, so that power is not wasted in needlessly supplying grid current to this valve.

On 80 metres, therefore, the V.F.O. excites the straight amplifier directly. In the meantime, the purpose of wafers (b) to (d) inclusive can be ignored. On Position 2 of the wave-change switch, wafer (a) closes the circuit of the input link to the first multiplier, and wafers (e) and (f) connect the amplifier input link to the output link of the first doubler. The amplifier is therefore excited on the 40m. band. On the next position of the switch, wafers (e) and (f) connect the amplifier link to the output of the second doubler, which brings the frequency to the 20m. band, while Position 4 of the switch excites the amplifier from the output of the third doubler, on the 10m. band. The purpose of the three extra wafers (b) to (d) inclusive is to turn on the H.T. supply only to those doublers that are needed, and at the same time to connect across the H.T. supply 20k. resistors which act as dummy loads for the power supply and ensure that, whatever band is in use, the H.T. drain is nearly constant.

CIRCUIT OF THE AMPLIFIER

The circuit of the amplifier portion of the exciter, as shown here, is intended to be diagrammatic only, so that the one diagram shows the complete set-up of the exciter. The exact circuit of the amplifier must clearly differ from the schematic shown, in one or two details. For example, no means have been shown for protective bias, to take care of mistuning during adjustment, or of failure of the excitation. Also, many users will probably wish to key this stage, and no connections are shown for this. Basically, the circuit is the one which will be used, and with the above two modifications will do admirably. In practice, too, metering arrangements must be provided.

POWER REQUIREMENTS

The doublers are all intended to run off an H.T. supply of 250 volts. At this, they will provide plenty of excitation for the straight amplifier, and will draw approximately 16 ma. cathode current each. Thus, we get output on all bands for an H.T. requirement of only 250 volts at 50 ma.—a very modest amount—which speaks well for the efficiency of EF50's as doublers. The QE04/10 stage, with its two valves, requires approximately 100 ma. at 250 volts, so that our 15 watts or so of output on 10 metres is costing us only 37.5 watts of H.T. input power.

The next Experimenter will discuss the circuit fully and will give the necessary mechanical details for constructing the unit.

GOSSIP

(Continued from page 43.)

NASH AND THE ASHES

While in Auckland recently, the Hon. Walter Nash visited the factory of Radio (1936) Ltd., his purpose being to bring himself up-to-date on secondary industries, and to assure himself that the policy now being followed on import control was fully justified.

The lunch-hour recess afforded him the opportunity of addressing the staff in the spacious cafeteria, when he expressed great satisfaction with the conditions of the workers, and remarked on the happy smiling faces. His remarks were both serious and humorous, ending with his telling the story of the man who died, leaving his wife instructions to have his remains cremated and his ashes enclosed in an envelope addressed to Hon. Walter Nash, Minister of Finance, Wellington, together with a note reading, "Now you've got the lot."

* * * *

Don Cooper, of Messrs. Green and Cooper, Ltd., has been in the South Island recently supervising the installation of Pye A.M. Radio Telephone Systems operating on 100-108 mc/s. channel for the Christchurch and Dunedin Fire Brigades.

* * *

Roy Stephens, of N.Z. Industries, Auckland, was a visitor to Wellington during March.

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We extend our sympathy to Bill Neighbours on the passing of his mother on 3rd March.

BEGINNERS' COURSE

(Continued from page 29.)

there are always some invisible components that do not appear on the circuit diagram. This might seem to be a difficult thing to understand, but in reality it is quite simple. Our next instalment will commence by explaining what we mean by this.

(To be continued.)

QUESTIONS AND ANSWERS

(Continued from page 22.)

difficulty in making the search coil oscillator go on this frequency without too many turns. A suitable coil for the fixed oscillator would be a 100 kc/sec. B.F.O. coil, which can now be bought as a standard component.

APPLYING THE 8012

(Continued from page 40.)

CYLINDER DIMENSIONS

A cylinder was made up with the following dimensions. Length, 2⅛ in.; outside diameter, 1 in.; wall thickness, 1/16 in.; gap, ⅛ in. This tuned to the following frequencies with the stated values of grid condenser:—

Grid Condenser	Frequency
5 $\mu\mu$f.	450 mc/sec.
10 $\mu\mu$f.	432 mc/sec.
15 $\mu\mu$f.	403 mc/sec.

Another cylinder made—length 1 9/16 in., other dimensions the same as above—gave a frequency with a 5 $\mu\mu$f grid condenser of 438 mc/sec.

Power can be coupled out of these oscillators by means of a single-turn link coupled to one end of the cylinder.

DRIVER FOR THE 144 mc/sec. AMPLIFIER

In our next issue, we hope to describe a driving unit with an output of approximately 6 watts output, which can drive the 8012 amplifier described here to grid currents of 20 ma., and which will allow operation at 700 volts, 100 ma., with a power output on 144 mc/sec. of over 35 watts into the aerial.